PARK SCIENCE

A RESOURCE MANAGEMENT BULLETIN

NATIONAL PARK SERVICE
U.S. DEPARTMENT OF THE INTERIOR

VOLUME 5 – NUMBER 2 WINTER 1985

PARK SCIENCE

NATIONAL PARK SERVICE

WINTER 1985

A report to park managers of recent and on-going research in parks with emphasis on its implications for planning and management

In This Issue

Cover Photo:
***Fishery Biologist** Jim Harrington holds a juvenile steelhead trout for dye marking of its fins, at Redwood Creek estuary.*

Interpretation is putting it all together.

The best interpretation takes the widest ranging sets of facts available and presents them in such a way that the subject matter takes on new depth and dimensions, complete with hooks and tie-ins to the experience of the "audience."

As scientists and resource managers have pursued their objectives in the fields that make up the National Park System, a whole world of fascinating raw material for interpretation has been emerging. Not only does this information make for exciting visitor experience, it is a "natural" for imparting management messages . . . from the "whats" of visitor safety to the "whys" of tough management calls.

It's one thing to put up a sign that says "do this" or "don't do that." It's quite another thing to fold into park interpretive programs and brochures the underlying scientific reasons for the dos and don'ts of visitor management.

Much of the scientific information available to interpreters is simply that – information. It can be used to frame, enhance, deepen, embroider – even to plant some eternal questions about – the basic subject matter for which the park was established. An article in the NPS Ranger Newsletter *(see Information Crossfile, this issue) suggests that interpretation is a four-fold program, with enrichment at the "recreational/inspirational" level as the most suitable "philosophical foundation upon which to base programs."*

Dick Cunningham, with strong backing from Western Regional Director Howard Chapman (see p. 17 this issue), goes straight for the heart of the other three "folds" – interpretation as (1) a management tool, (2) an educational tool, and (3) a tool for attitude change. All three of these can become valuable adjuncts to wise visitor management.

In the Southwest Region, Keith Yarborough (see p. 9) recognized the results of air quality research in the great scenic parks of the West as a gold mine of interpretive information and did something about it. With superb support from the Denver science team and the Southwest Regional interpretive division, he not only spread the facts before interpreters from three NPS Regions, but gave them the materials from which to build meaty, well-received, management-supportive visitor programs.

There must be other such success stories out there, either in place or in the making. We'd like to hear about them – the things that worked and the things that didn't. Wherever the gap between interpretation and scientific research is closed, a whole host of benefits emerge: the fruits begin with better public understanding of the national parklands, extend to greater support for necessary management decisions, and wind up making park interpretation a richer, more integrated part of the total NPS experience.

RUSSELL E. DICKENSON, Director
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ISSN-0735-9462

Reviving Redwoods
(Part II)

By Robert Belous

By Robert Belous

Erosion control efforts during the past five years in Redwood NP have brought a measurable degree of stability to a landscape otherwise beleaguered by aftereffects of clearcut logging. (See " View From Redwood Creek", Winter 1984 issue) But stabilized slopes alone do not a redwood forest make, or remake. Several parallel programs in resource management and applied science add important aspects to the park's rehabilitation efforts that will help assure the return of a self-sustaining ecosystem from crowning redwoods to critters of the forest floor, and provide a sound data base for future management needs.

A comprehensive soils mapping regime is being conducted across 51,000 acres of the Redwood Creek watershed. The terrain ranges in elevation from near sea level to the park's highest ground at 3,097 feet and includes the 36,000 acres of logged lands added to the park in 1978. Soil mapping of the watershed is being conducted in conjunction with the Soil Conservation Service and is slated to continue through December 1985. Field investigations and ground truthing of soil horizons are aimed at detecting areas down to 10 acres in size that require specialized techniques for watershed rehabilitation, erosion control and fire management.

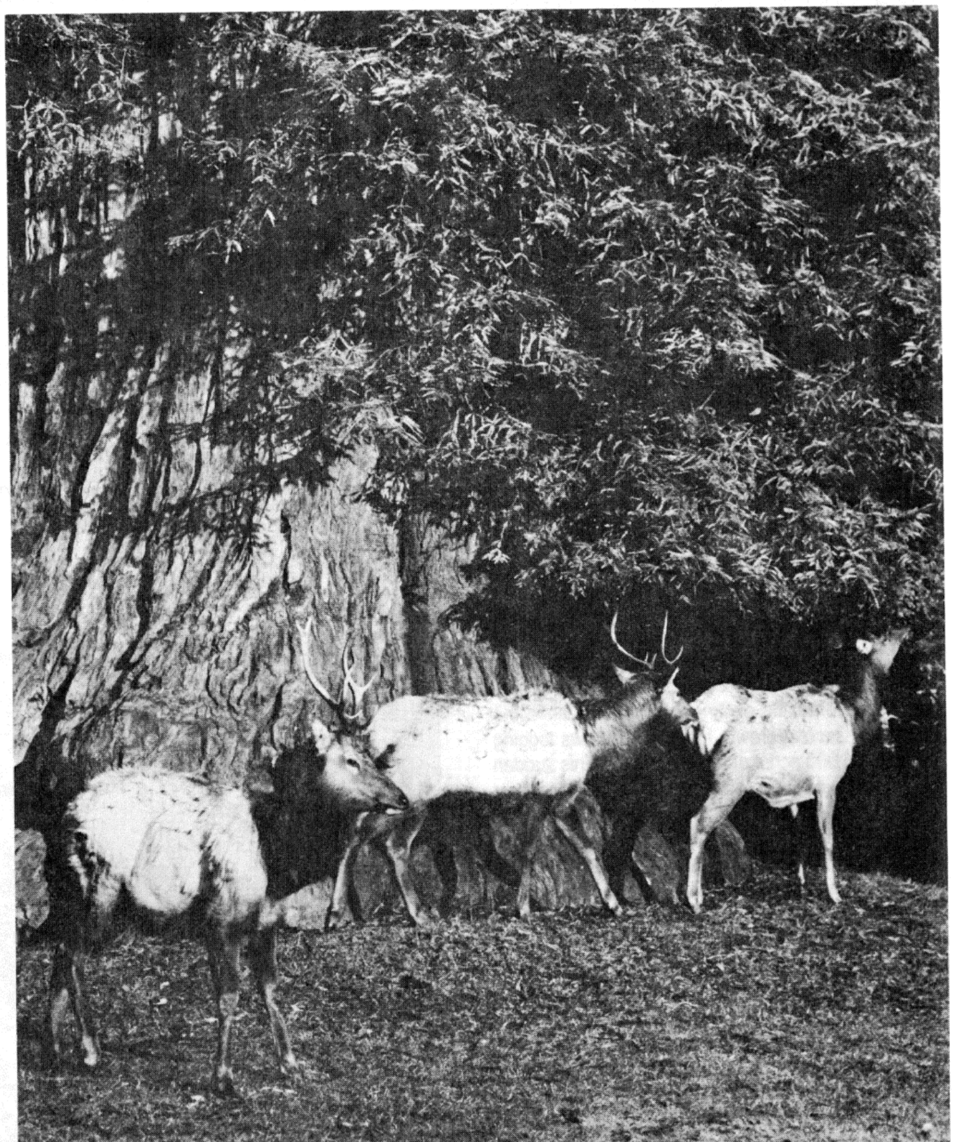
Levels of mapping detail for rehabilitation zones are refined to 1:6,000 scale linear transects. Each transect segment is 100 feet or longer and corresponds to minimum delineated areas of about 0.25 acres. Such zones also are mapped at 1:12,000 scale using black and white aerial photographs with maximum size contrasting inclusion of 10 acres. Coverage for additional logged lands and adjoining prairies and oak woodlands include color infrared imagery to delineate special vegetation patterns associated with wet terrain and slopes susceptible to mass movement.

Ten major soil types have been identified thus far, where they occur in areas of 2,000 acres or more. A series of descriptions and names for these soil classifications has been propsed and submitted to the soil Conservation Service for possible adoption into standard usage. If accepted, the lexicon of soil science would be expanded by such local sobriquets as *Ahpah* and *Devilscreek,* both depicting examples of *Inceptisol* soil found on relatively young geomorphic surfaces of late Pleistocene or Holocene age. The inceptisols are the dominant soils order of the park's mountain slopes. Other orders treated in the mapping regime are *Alfisols* (found in wet places underlain by clay-rich colluvium and subject to mass movement); *Entisols* (dominant mineral soil content and lack of distinct soil horizons, found on streamside alluvial flats); and *Ultisols* (a reddish soil occurring on well-drained, older geomorphic surfaces and with signs of intense mineral leaching). Thus the subtle chemistry of Redwood Creek's panoply of basic soils emerges for the first time.

Methods of revegetation for rehabilitation sites have undergone considerable refinement over the first few years of the program. Initial techniques, for example, included use of "willow wattles" along terraced slopes. These bundles of woody branches were partially buried in contour trenches and produced the first sprouts of soil-firming vegetation. Wattles comprised an effective barrier to ravelling of soils on steep inclines and also helped prevent the formation of rills – the tiny rivulet precursors of erosional gullies – with the onset of winter rains. But comparative costs per linear foot were high. And summer drought conditions along many exposed rehabilitation sites took a heavy toll on young willow sprouts. Another disadvantage was the often intense impact of browsing. California blacktail deer display a notable fondness for tender willow shoots. Wattling was discontinued in 1980.

Early revegetation methods also utilized transplanted stock, stem cuttings and wood chips. Dairy barn by-products were tried, but with little success. Even planting of grasses proved counterproductive. Grasses in redwood environs tended to inhibit reestablishment of such beneficial shrubs as coyote brush and salmonberry, which are successional shrub species whose root systems aid in stabilizing clearcut hillsides. This new insight was not without some spinoff benefit. While use of grasses was largely discontinued for redwood environs in the park, the practice proved cost-effective at nearby Siskiyou National Forest. Suppression of shrub growth by competing grasses on commercially harvested timber lands diminished the need for chemical defoliants otherwise used to speed timber regeneration.

Current restoration practice in the Redwood Creek watershed places major emphasis on site preparation; that is, decompaction of old road surfaces and accurate recontouring of original stream channels



***Roosevelt elk** at the base of a mature redwood tree. Elk herds of Redwood National Park are the subject of a research program to determine carrying capacity and choice of seasonal habitats, as well as the make-up and distribution of the herds.*

and surrounding terrain. Any portion of the original A-horizon, or topsoil, that can be salvaged is carefully replaced. It has been shown that a higher degree of restorational success is attained by use of the original topsoil than by attempting to upgrade a C-horizon (mineral soil) with costly infusions of fertilizer.

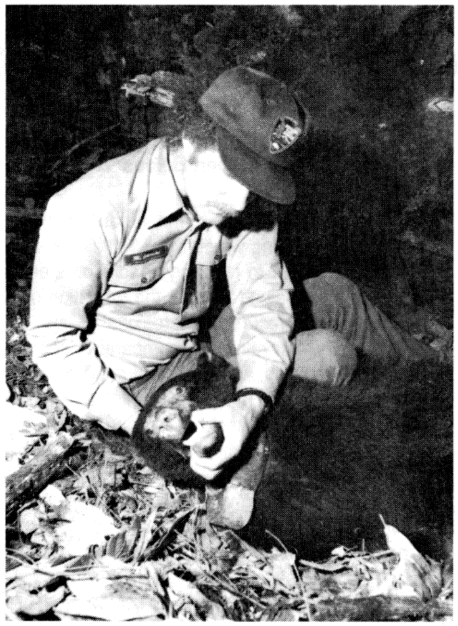
Newly prepared sites are spread with straw mulch. This practice replaces the formerly used method of planting nitrogen-fixing legumes, such as subclover *(Trifolium sp.)*. Monitoring of treated sites has shown that subclover competes for scarce water during summer dry periods with seedling root stock of redwood and Douglas fir. Typical restoration sites will be planted at 6 to 8 foot intervals with redwood and Douglas fir root stock. And fast-growing red alder often is used along stream channels and erodable banksides. Thus far, survival rates for vegetation run between 50 and 80 percent. Where substantial losses have occurred, the problem usually is related to fungus infection of the root stock and, in some cases, heavy browsing by elk and deer.

Upslope and along the eastern ridgeline of Redwood Creek are adjoining prairies where revegetation of road scars has involved a compromise with non-native species. Prior to the turn of the century, these rolling grasslands were covered predominantly with California oatgrass *(Danthonia californica)* and blue wild rye *(Elymus glaucus)*. Since the 1850s, however, the area has been invaded by numerous exotics, such as soft chess *(Bromus mollis)* and subclover. Given the present mix of about 50/50, native to non-native, the occurence of well-established exotics at rehabilitation sites has become a working compromise beyond reasonable remedy.

Historical evidence shows that the park's prairies were to a measurable degree dependent upon and a product of human activity. Periodic burning by aboriginal Indian people helped renew stocks of harvestable plants, such as Indian potato (*Brodiaea sp.)* and certain shrubs used in weaving basketry. The burning also created forage attractive to elk and deer, which in turn were harvested for food. Since the 1850s, when the practice of burning was abandoned, the prairies have lost more than 30 percent of their acreage to encroaching forest. As a step toward maintaining the prairie grassland environs, a regimen for periodic controlled burning is being considered as part of the park's fire management plan.

Fish and wildlife of the Redwood Creek watershed have undergone a varying range of impacts through habitat destruction from logging and forest renewal. Black bear, Roosevelt elk and blacktail deer now are enjoying a dramatic expansion of habitat amid the shrub-rich second growth forest that follows logging of some 36,000 acres of redwood trees. This sudden supermarket of edible plantlife has resulted in an increase of population, though exact comparisons cannot be made due to a lack of pre-logging data. What is clearly predictable, however, is that a downward adjustment of animal numbers eventually must occur, as surely as the tall trees regain their dominance and lush undergrowth habitat shrinks. In some locales, exceedingly thick stands of Douglas fir – referred to as "dog hair" forest – already appear rich and green but are almost devoid of sustaining habitat for deer, black bear and elk. In the case of black bear, an elevated population and a diminishing habitat, viewed against potential bear interaction with park visitors, suggests a serious and timely warning.

To better gauge trendlines between wildlife and the changing carrying capacity of a recovering redwood forest, several studies have been undertaken. A series of black bears have been fitted with radio collars and have been monitored for movement, choice of habitats, and denning sites and duration. The collars are sensitive to motion and the angle of the animal's head, and thus provide a measure of daily activity as well as location.



Biologist Mark Schroeder *checks the condition of a radio-collared black bear that has been immobilized with a tranquilizing drug.*

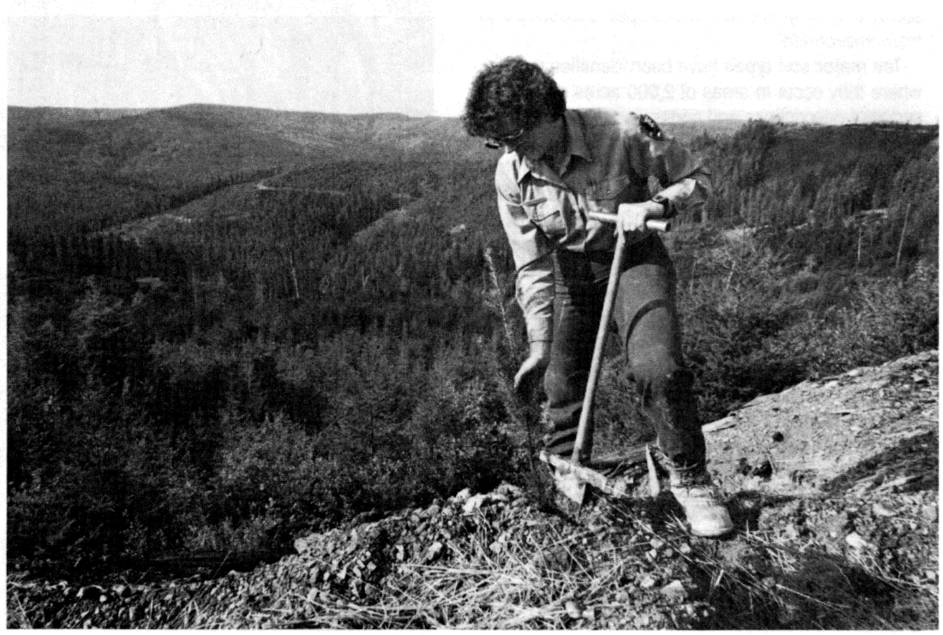
Periodic trapping of bears also offers an indication of an individual specimen's vigor in relation to its age and habitats used. Preliminary findings show that bears inhabiting cutover areas of generally homogenous age and vegetation type show a relatively poor weight-to-bone frame ratio, or a kind of "compromise physiology." Although the exact causes for such discernible differences in bodily condition are not yet fully understood, at least some of the data and observations suggest that habitat variety is an important factor for bears in the redwood environment. Blood samples taken from trapped bears also yield insight into seasonal blood chemistry. Such factors as glucose levels and creatinine phosphates are considered a kind of bedrock measurement of an individual's physiological condition.

Combined with such resource information as regional soil characteristics and the prognosis for revegetation, an overall picture of the black bear's relationship to a changing habitat begins to emerge. The information allows for sound planning of visitor use areas and protection of critical habitats. An area known as Bridge Creek Ridge, for example, has been found to provide good year-'round habitat of importance to bears. A relatively open forest canopy allows a diversity of such seasonal forage as salal berries, huckleberries, oak (acorns), forbes and grasses. These characteristics make the Bridge Creek area important for bears and also militate against development that would bring people and bears into direct (and needless) competition. A similar research effort relating to Roosevelt elk was initiated during the 1984 summer season.

As with any basic research program, certain unexpected benefits and insights have come from the black bear investigations. Blood samplings from live-trapped bears offered a chance to test for the occurence of sylvatic plague – long surmised to be unrepresented in redwood environs. Of 42 bears sampled, one-third showed positive exposure to plague through presence of blood antigens. Further observations linked possible exposure to bear denning sites that were found associated with active wood rat nests. Subsequent tests of wood rats showed appreciable levels of antigen titers.

Sylvatic plague is a contagious disease caused by the bacterium *Yersinia pestis,* carried in the stomach of fleas. The disease can be transmitted to humans (as bubonic plague) through flea bite or directly (as pneumonic plague) from person to person. Field research on occurence of sylvatic plague in Redwood NP is being conducted in conjunction with the California Department of Health Services.

The revival of Redwood Creek's aquatic habitat is



Two-year-old Douglas fir *is planted by Technician Bonnie Griffith along a rehabilitation site on the eastern flank of Redwood Creek. Zones of clearcut logging can be seen in the distance, along with an old logging road slated for rehabilitation.*

one of the notable rehabilitation achievements. Erosion control measures have stemmed the mass wastage of hillsides and old logging roads. And, though the creek bed has yet to undergo passage of many years' worth of logging-related sediment, stream disturbances have lessened to the point where fishery habitats are reforming. The modest-sized waters of Redwood Creek once supported a substantial fishery of steelhead trout, salmon and cutthroat trout. King salmon were known to run upwards of 50 pounds, and a commercial fishery operated during the 1920s for markets in Eureka, 30 miles south. Given the severity of logging impacts, it may require decades of recovery for the stream to approach its former stature as a fishery.

Loss of rearing habitat for juvenile fish appears to be the limiting factor in recovery. Only three holding pools have been found during a recent survey of the lower 18 miles of the stream. The sediment mass introduced by logging-related erosion has virtually eliminated the entire three- and four-year old age classes of steelhead trout. Yet a continuing program for trapping and marking down-migrating juvenile fish has shown a positive though modest increase in populations and growth rate for salmon and steelhead. Cyclic monitoring of water conditions (e.g., dissolved oxygen, temperature and aquatic invertebrate populations) also is performed, and this helps to match production of fish with habitat carrying capacity.

Biological survey efforts also have brought to light the occurrence along the creek's main stem of "cold pools," used by significant numbers of steelhead and salmon. These pools are consistently 4° to 8°C lower in temperature than the 25°C of the creek's main stem. Fed by separate sources of groundwater, these cold pools may comprise important refugia for salmonids during critical periods of low water flow and high summer temperatures. This small but important habitat could help sustain the watershed's decimated fish stocks through the years needed to fully stablize erosion and revive spawning and rearing habitats.

From the overall picture of the watershed and its fishery, the most serious bottleneck limiting full restoration lies in the creek's lower estuary and embayment. Construction of almost three miles of flood control levee following a local flood in 1964 has appreciably reduced juvenile rearing habitat at its final stage, the stage which prepares young smolt salmonids for survival in an ocean environment. In its present configuration, the estuary cannot accommodate full output from upstream spawning habitats as the positive effects of erosion control and rehabilitation continue to increase.

Park staff is currently consulting with the Army Corps of Engineers on methods of levee modification. The goal is to recover once-productive habitat while maintaining adequate flood protection for residents of the adjacent town of Orick. The effort is noteworthy, though the locale is miles removed from the park's stately redwood groves. Reestablishment of a thriving and healthy fishery in the Redwood Creek watershed may be the ultimate measure of success for a decade's worth of erosion control and rehabilitation.

Belous is Resource Management Assistant to the Superintendent at Redwood NP.

***Juvenile salmon** from Redwood Creek is weighed by Fishery Biologist Randy Brown. The fish is temporarily immobilized by use of a mild drug.*

meetings of interest

The Southwestern and Rocky Mountain (SWARM) Division of AAAS will hold its 61st Annual Meeting in Tucson, Arizona March 19 to 23, 1985. AAAS President David A. Hamburg will give the keynote address and Peter Raven, Missouri Botanical Garden director, will deliver the John Wesley Powell Memorial Lecture. Symposia will include those on Quaternary Extinctions, Macromolecules of Biological Interest, Interactions Among Plants and Animals in the Western Deserts, and Biotechnology – Interaction of Disciplines. Contact is M. Michelle Balcomb, SWARM/AAAS, Colorado Mountain College, 3000 County Road 114, Glenwood Springs, CO 81601 or (303) 945-5516.

"Arid Lands: Today and Tomorrow," an international research and development conference, will be held in Tucson, Arizona Oct. 20 to 25, 1985. The call for papers covers all topics relating to arid lands water use and conservation, agricultural systems and genetic resources, natural resource management, conservation and reclamation, human adaptations, migrations, and habitations. Co-sponsors are AAAS, UNESCO, U.S. AID, the U.S. MAB Program, and the University of Arizona. Contact is G. P. Nabham, Office of Arid Lands Studies, University of Arizona, Tucson, 85721.

The International Union of Forest Research Organizations' Division 1 Working Party (Natural Parks, National Parks, and Wilderness), will hold its first meeting in conjunction with the U.S. National Wilderness Research Conference at Fort Collins, Colo., on July 22, 1985. The National Wilderness Conference meets July 22-26. Agenda for the Working Party will cover three topics:

(1) A scientific agenda for the Fourth World Wilderness Congress, to be held in Colorado in 1987; (2) problems in using wilderness for scientific research; and (3) scientific definitions of wilderness. Each session will be keynoted and parties interested in presenting papers on these topics should contact Dr. Jerry F. Franklin, Forestry Sciences Lab, 3200 Jefferson Way, Corvallis, OR 97331.

George Wright Society and NPS Set 1986 Science Conference

NPS Branch of Water Resources staff members will support the National Park Service and the George Wright Society in preparation for a conference on research in the national parks, to be held in Fort Collins, Colo., July 13 to 20, 1986.

The conference is the fourth in a series that began in 1976 in New Orleans, sponsored by NPS and the American Institute of Biological Sciences, continued in 1979 in San Francisco, and was held again in Washington, D.C., in 1982 under the joint sponsorship of NPS and the GWS.

Co-chairmen for the 1986 conference are Ray Herrmann for natural resources and Calvin Cummings for cultural resources. Tentative theme of the conference is "Interrelationships of Man and His Environment."

Long Distance Transport Of Man-Made Air Pollutants

By Donald Henderson, Mei-Kao Liu, and Douglas Stewart

Dangers of air pollution to human health and threats of air pollution damage to areas with sensitive resources have been investigated for over a hundred years. In recent years scientists have become more aware of ecological damage caused by man-made airborne pollutants in areas remotely located long distances from air pollution source regions. Since the advent of nuclear weapons at the close of World War II and subsequent testing of nuclear devices by various countries, the observed wide spread of radioactive materials has made scientists more keenly aware of long-distant transport of man-made air pollution.

World-wide industrialization during the past century has caused an increase in use of fossil fuels, which in turn has increased the amount of pollution in the atmosphere. Long-distant transport of pollutants is believed to make a significant contribution to acid deposition in Europe, United States and Canada. Naturally produced substances also are transported long distances and interact with man-made pollutants to further complicate our understanding of causes and effects of air pollution.

Global monitoring at selected locations throughout the world is being conducted to detect long-term changes which may be occurring in the total global pollution burden resulting from long-distant transport of air pollution. In recent years satellite photographs and global monitoring have detected pollutants long distances from their point of origin. Nuclear debris injected into the atmosphere over mainland China has been measured at high altitudes over the western United States. Recent volcanic eruptions of Mount St. Helens in Washington, and El Chichon in Mexico spewed pollutants into the upper atmosphere. The pollutants were transported long distances downwind from the source areas causing high enough concentrations to be detected by monitoring equipment at various locations on the earth. Desert sands from the Sahara Desert occasionally are entrained into the atmosphere by strong winds and transported as far away as Europe and the Antilles Islands.

Regions of the earth near heavily industrialized areas, and even regions remotely located several hundred miles from heavily industrialized areas, are affected by air pollution emitted by man's activities. The main pollutants of concern are: sulfur dioxide, oxides of nitrogen, carbon monoxide, carbon dioxide, hydrocarbons, particulate matter, lead, and others.

During the past decade, monitoring studies have indicated a trend toward decreasing air pollution concentrations in urban areas. This trend is probably the result of air pollution control strategies that have been implemented as a result of tighter air pollution regulations. Additional controls may be necessary to reduce danger to human health and reduce threats of air pollution damage to sensitive resources. For example, there is evidence that increasing carbon dioxide from burning of fossil fuels will enhance the atmospheric "greenhouse effect" and cause a global warming trend that will result in undesirable climatological changes on a global scale.

In recent years, scientists have become increasingly concerned with the possibility of man's activities depleting the stratospheric ozone layer. Chlorofluorocarbons (CFCs, more commonly known by the trade name Freon) released into the atmosphere can become widely distributed in the global circulation patterns, and reduce ozone concentrations in the stratosphere. Depletion of the ozone layer would allow increased transmission of ultra-violet radiation to the surface of the skin, possibly increasing the incidence of skin cancer. Because of this concern, manufacturers in the U.S. have been regulated to discontinue use of Freon in spray cans. However, CFCs continue to be used in many parts of the world.

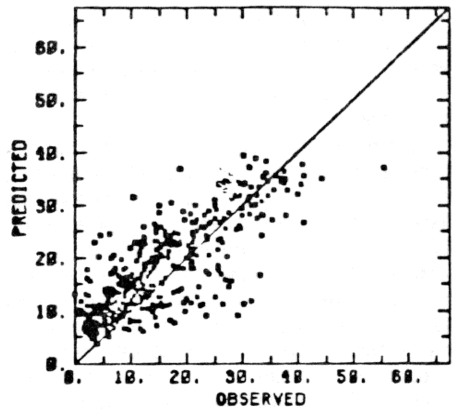


FIGURE 2 Scatter plot of predicted and observed 24-hour average concentrations. (Units are $\mu g/m^3$).

Photochemical oxidants, which are caused principally by incompletely burned fuel emitted by motor vehicles, have been measured at locations long distances downwind from metropolitan areas. Other man-made pollutants that are transported long distances and about which scientists are very concerned are sulfur oxides, nitrogen oxides and fine particulate matter. The long-range transport of these pollutants may impair atmospheric visibility, increase acidic deposition and cause significant adverse ecological effects at locations long distances from the source regions.

To a certain extent, the atmosphere is an efficient pollutant diluting system. Wet and dry deposition processes, and dispersion of pollution by fluctuating winds tend to dilute and cleanse the atmosphere of pollutants. There is evidence that the reduction of

(a) Daily (July 21, 1984) *(b) Annual (October 1977 - September 1978)*

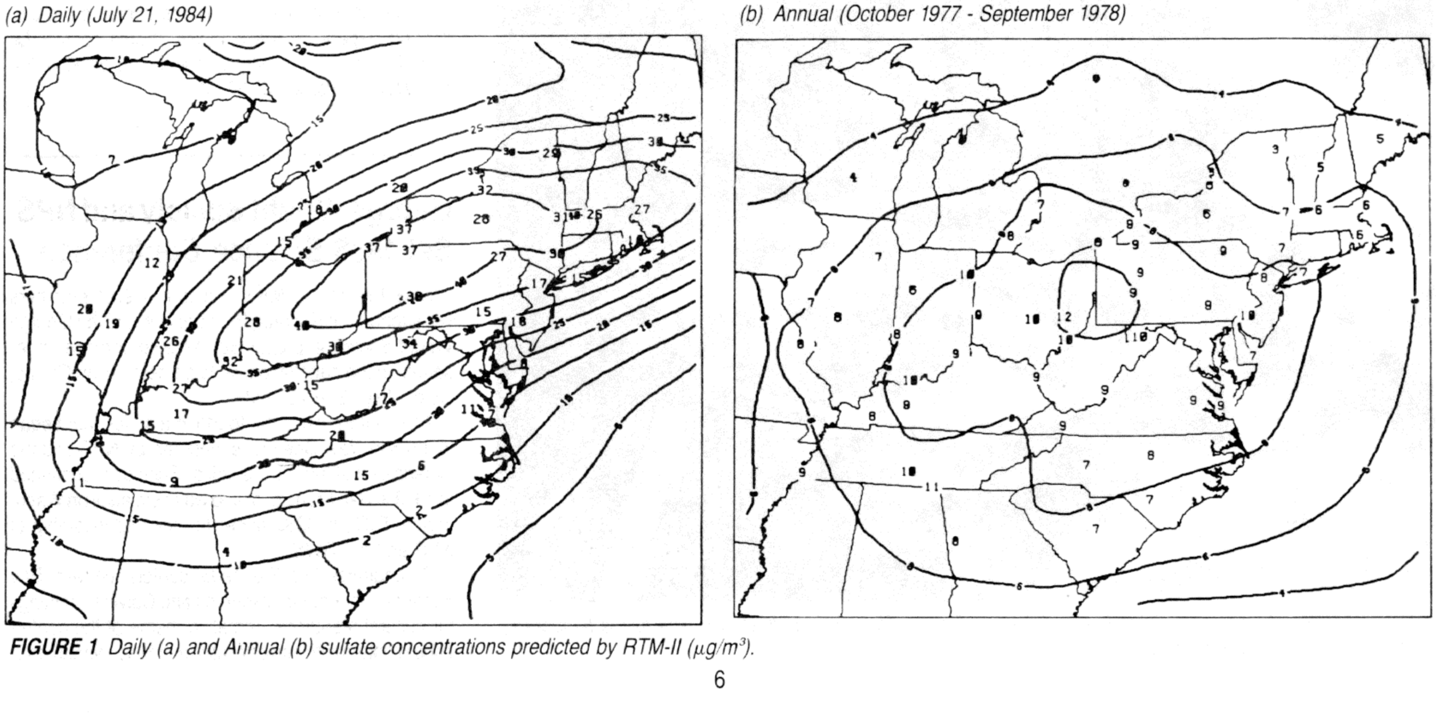


***FIGURE 1** Daily (a) and Annual (b) sulfate concentrations predicted by RTM-II ($\mu g/m^3$).*

sulfur emissions since the early 1970s in the U.S. has resulted in a proportional reduction in deposition of sulfur dioxide and sulfates to the earth's surface. If control strategies can be proven beneficial, then further action is needed to prevent undesirable and irreversible damage to ecological systems. A great deal of controversy surrounds control strategies because they affect not only the environmental element, but social and economic elements as well.

Why should the National Park Service be concerned with these issues? Lands managed by the Service are unique, with natural resources that are highly sensitive to man-made pollutants. To protect such resources, both the causes and effects must be studied to determine the source-receptor relationship. A task force appointed by the Environmental Protection Agency has found that some national parks such as Grand Canyon and Shenandoah are being damaged by pollution from distant source areas. The task force is finding that statutory or regulatory changes to existing laws may be necessary to protect national parks from air pollution.

Assessment of existing conditions is essential. Two approaches generally are used. One is to conduct extensive, expensive measurement in areas where effects are known, or suspected to exist. Such measurements, often limited in scope by inadequate funding and too few personnel, are being conducted in certain areas. Another approach is to use mathematical models to make such assessments. Transport, dispersion, chemical transformation, and wet and dry deposition of pollutants are analyzed by the models. However, if models are used, they must be tested and

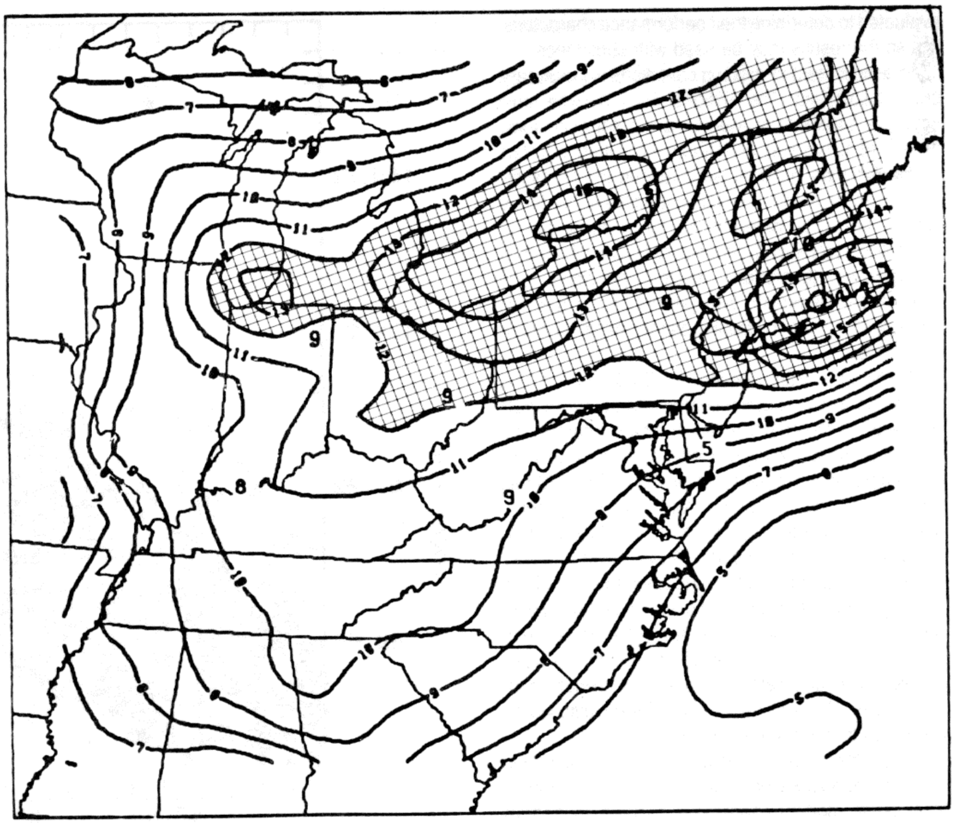


FIGURE 3 *Predicted ozone concentrations in the mixed layer (pphm) on 20 July 1978 from 1400 to 1500 EST.*

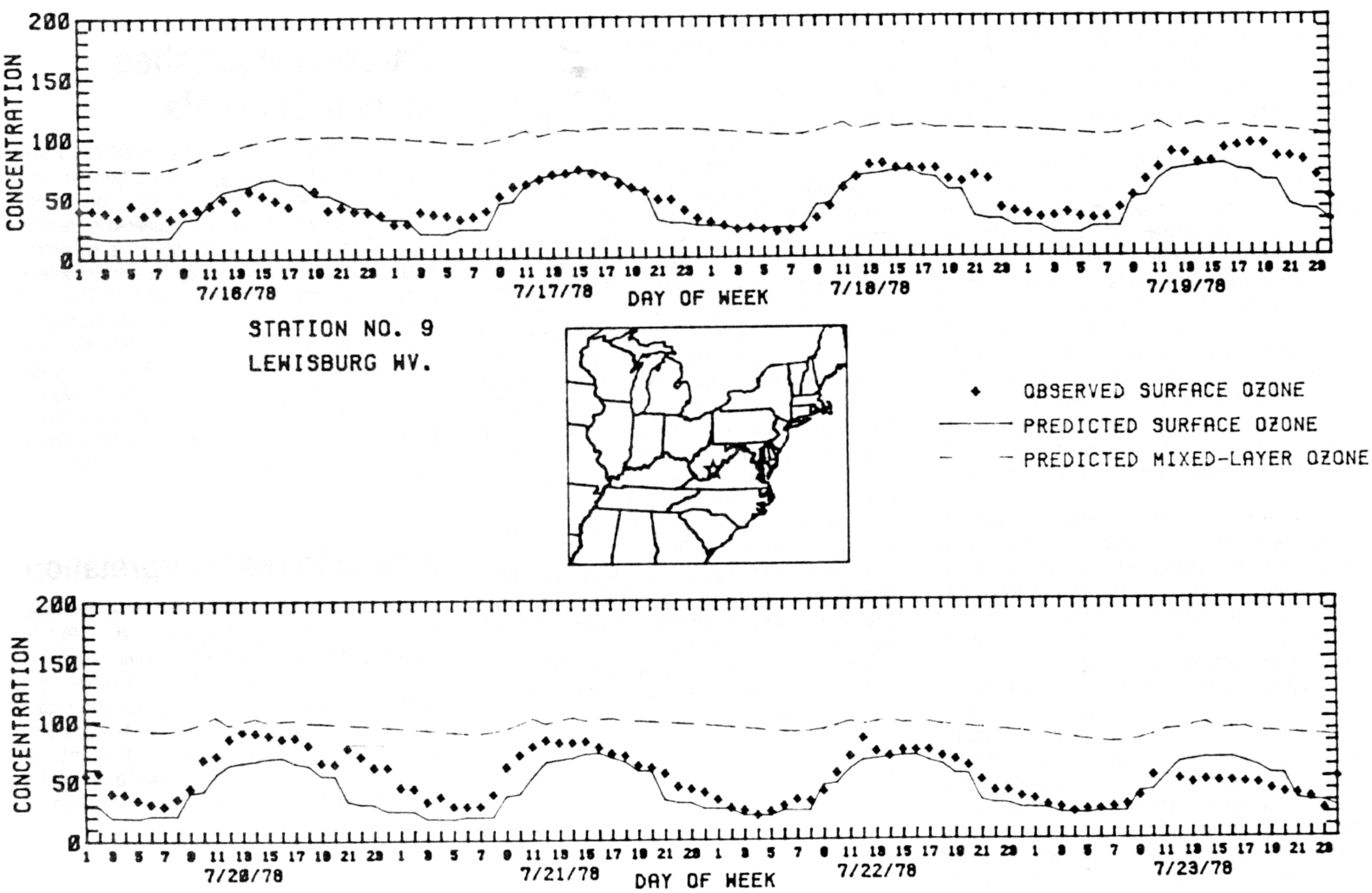


FIGURE 4 *Time History of Hourly Ozone Concentrations (ppb).*

evaluated to determine their performance characteristics so the results may be used with confidence.

An assessment of existing conditions is necessary, but not sufficient. The National Park Service must have the capability of assessing current conditions, as well as assessing the influence of future activities of mankind on national park resources. Measurements can be made of existing conditions, but future conditions can be determined only by some type of estimation technique. Mathematical models based on well-founded theoretical physical principles and evaluated to determine their performance capability, are valuable tools in making assessments of future conditions.

The National Park Service, Air Quality Office, has contracted a four-phase research effort over the past five years to develop and test mathematical models to be used for assessing long distant transport of man-made pollutants. A mathematical model (RTM-II) has been developed, evaluated, and is currently being applied to simulate sulfur dioxide and sulfate concentrations in four national parks (Acadia, Great Smoky Mountains, Mammoth Cave, and Shenandoah) where existing air pollutants are suspected of damaging park resources. The model will be applied in other areas as needed. Another version of the model has been developed to calculate photochemical oxidant concentrations. This version, named RTM-III, also will be applied to these four national parks.

Prior to the models being applied in national parks, model calculations were compared to measurements to evaluate model performance. Figures 1a and 1b show examples of the model calculations for daily and annual average sulfate concentrations. The isopleths for Figure 1a are plotted for 5 $\mu g/m^3$ increments. The measured concentrations also are plotted for easy comparison with calculations. Figure 1b illustrates annual average sulfate calculated concentration isopleths as well as measured values. The isopleths for annual average sulfates are plotted in 2 $\mu g/m^3$ increments.

Figure 2 shows a scatter plot of observed versus predicted, 24-hour, sulfate concentrates. The scatter plot indicates that the model simulates sulfate concentrations quite accurately. The model also was used to simulate sulfur dioxide concentrations, however, the estimates were less accurate. The greater ability to predict sulfate concentrations can be explained by the nature of the two pollutants. Sulfate is formed as a secondary pollutant downwind of sources that emit the precursor sulfur dioxide. At these downwind distances, turbulent dispersion and chemical transformation have resulted in more uniform concentration gradients. The sensitivity of concentration predictions to slight error in transport or removal rates is therefore reduced.

The ability of the model to simulate the distribution of high, as well as low sulfate concentrations is quite good despite the tendency to overpredict low concentrations and to slightly underpredict high concentrations. The overall correlation coefficient of 0.8 indicates that 64 percent of the variance in all observations can be explained by the model.

RTM-III was used in a pilot study to estimate the distribution of photochemical oxidants at eight locations in the eastern United States. Figure 3 illustrates an example model result for July 20, 1978 at 1400 hours. The cross-hatched area indicates the region where ozone concentrations are estimated to exceed the 1-hour standard (.12 parts per million). Figure 4 shows a time series plot of predicted and measured ozone concentrations at a particular station from July 16 to 23, 1978. The diurnal variation of predictions and measurements is clearly evident. The model estimates the variation of measured values quite accurately. The scatter plot, Figure 5, shows an overall trend for the model to over-predict small values and under-predict high values.

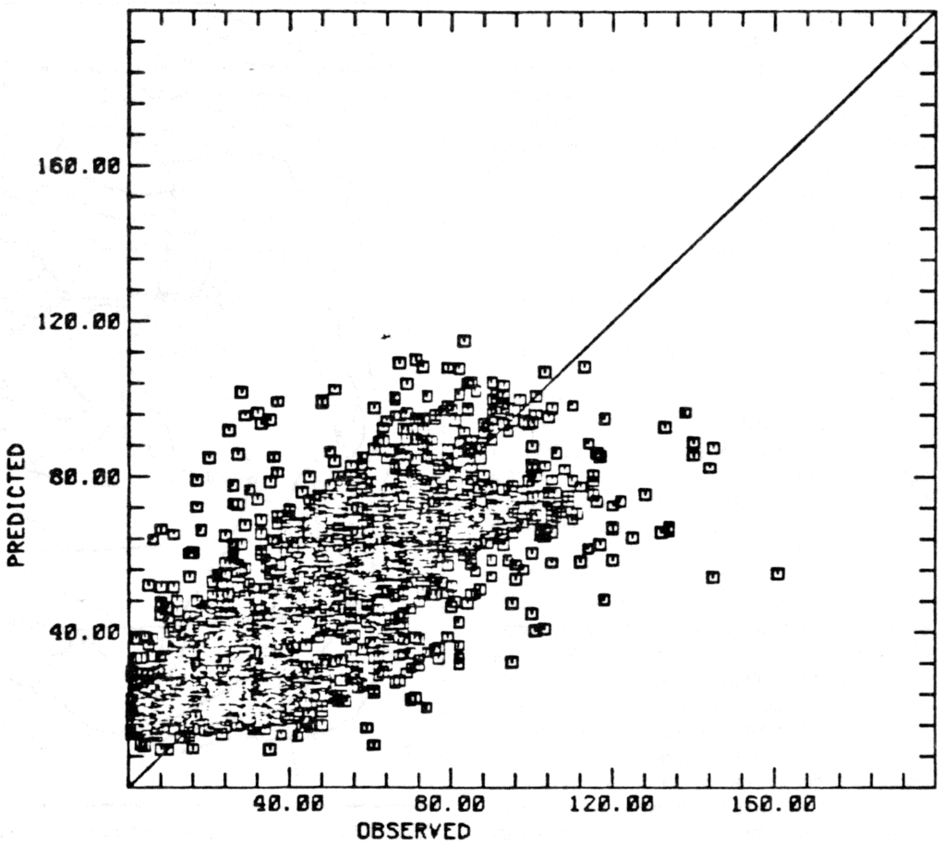


FIGURE 5 *Scatter diagram of the predicted and observed O_3 concentrations (ppb).*

In summary, the long-range transport models can be useful tools for application in estimating air pollution concentrations. They also can be useful for assessing regional atmospheric visibility degradation, and simulating wet and dry deposition of acidic substances to the surface. Control strategies and management decisions may be made using the model results. For example, the estimates made with RTM-II indicate annual average sulfate wet deposition in the general area of Shenandoah NP to be 25 kilograms per hectare per year for the year 1978. The U.S./Canada Transboundary Committee has indicated that chemical and biological effects are not observed when sulfate loading is less than 20 kilograms per hectare per year. Therefore, the model indicates that emissions reduction is necessary in source regions which affect deposition in Shenandoah NP.

The long-range transport models are valuable tools for estimating long-range transport of pollutants, and determining necessary pollutant emission reductions within pollutant source regions.

Henderson is a meterologist with the NPS Air and Water Quality Division; Liu and Stewart are with Systems Applications, Inc., San Rafael, CA.

Parsons Publishes in Two Journals

Three articles by David J. Parsons, NPS research scientist at Sequoia and Kings Canyon National Parks, have appeared recently in two journals. "Sensitive Plant Studies" in the parks appeared in *Fremontia* 12(3):14-19, with Larry L. Norris as co-author. "Post-fire Uptake of Nutrients by Diverse Ephemeral Herbs in Chamise Chapparal," with P.W. Rundel of UCLA's Laboratory of Biomedical and Environmental Biology, was in *Oecologia* (Berlin) 61:285-288, 1984. Also appearing in *Oecologia* (64:87-91) was "Population Structure of *Adenostoma fasciculatum* in Mature Stands of Chamise Chaparral in the Southern Sierra Nevada, California." Co-authors of the latter article are T.J. Stohlgren and P.W. Rundel, also of the UCLA lab.

Alaska Parks Interpretation

"The Challenges for Interpretation in the New Alaskan Parks," by R. Gerald Wright of the NPS/CPSU at University of Idaho, appears in the *Journal of Interpretation*, Vol. 9, No. 1, 1984. The paper outlines the basis for the new management policies with regard to Alaskan national parks, some ramifications they may have, and examples of training programs that may enable park naturalists to understand and explain these new policies to the satisfaction of the public.

Biosphere Reserve Management Meeting Held in Smokies

Editor's Note: *The MAB Biosphere Management Conference took place just as this issue of* Park Science *was going to press. Following is a short account of the opening sessions, as stage-setting for more detailed coverage of the presentations by workshop leaders and recommendations that still were taking place at press time. The fuller coverage will be carried in the Spring issue.*

"The success or failure of the Biosphere Reserve concept is directly related to the collective efforts that Biosphere Reserve managers provide to this program."

With these words, Roland H. Wauer delivered his opening day challenge to the MAB Conference on the Management of Biosphere Reserves, Nov. 27, 1984, in the Great Smoky Mountains NP.

Wauer, who is assistant superintendent in charge of science and resource management at Great Smokies, defined resource management as "A *process* of resource protection (that) incorporates all the pieces of a multi-disciplinary matrix into a comprehensive perspective for the long-term perpetuation of an area's natural systems."

"It is more than planning and implementation," he told the delegates. "It also involves interpretation, monitoring, and research."

He urged American and Canadian Biosphere Reserve area managers, many of whom were present, to grasp the leadership role in developing the biosphere reserve concept. "European countries expect and *want* America to take the lead in resource protection on a worldwide scale," he said.

Harold Eidsvik, senior policy advisor to Parks Canada, in his keynote address, complimented the Great Smoky Mountains NP managers for their successes in "preserving a sustained society, in an economic as well as a natural, social and moral sense."

This integration of human activities that sometimes seem poles apart became a central theme in Eidsvik's view of Biosphere Reserves. The extension of the biosphere reserve roles, beyond that of National Parks, was presented as "the integration of conservation, development, and society, for the betterment of people around the world."

In line with Wauer's challenge to managers, Eidsvik urged delegates to "develop pilot projects that *demonstrate* to the world the usefulness of Biosphere Reserves."

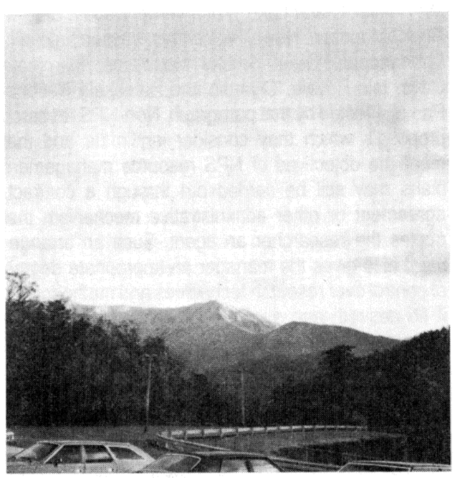
The key, Eidsvik said, is communications. A communications management committee would be a useful – perhaps even a vital – addition to every Biosphere Reserve area. Eidsvik stressed the need for public understanding and backing of Biosphere Reserve management's commitment to long-term management of ecosystems rather than short-term management of visitor facilities.

The role of protected areas is a vital part of the essential linkage between conservation, development and society, Eidsvik said. "None of these three is sustainable in isolation."

The conference workshops dealt with five areas: air pollutants, development of non-renewable resources, use of renewable resources, problem species, and visitor activities. Jack Moorehead, Everglades NP superintendent, summarized the workshop recommendations at the close of the conference.

The Sheraton Gatlinburg *hotel, where the conference was held in November 1984 on management of biosphere reserves. Sequoia/Kings Canyon Supt. Boyd Evison observed that the General Sherman Tree, if placed in the hotel lobby, would overtop the 15-story structure by more than 100 feet, "and if you looked out the 10th story window, you'd see the view from the first branch of the General Sherman Tree."*

The Great Smoky Mountains, *from the Sheraton Gatlinburg hotel parking lot, with Mount Le Conte in the center distance.*



Scientists 'Translate' Research

By Keith Yarborough

For six years now the National Park Service has been developing its air quality program – gathering data on the degradation of visibility, on how people perceive this degradation when viewing important vistas in National Parks, and on effects that air pollutants are having on sensitive park resources such as certain lichens and plants.

Two years ago, staff people in the Southwest Region saw the need to make a "translation" of these important findings for park managers, for rank and file park personnel, especially seasonals, and for the visiting public.

Starting in September 1982, planning was developed for an interpretive workshop that would begin to provide park interpreters in the Southwest, Western, and Rocky Mountain Regions with the facts they would need in order to shape air quality programs tailored to their own parks. Assistance was provided by the WASO Air Quality Division, particularly those technical experts on the Denver team.

The workshop was held in Santa Fe in late April 1983 and attended by line interpreters from Chaco Canyon, Bandelier, Capulin Mountains, Guadalupe Mountains, Big Bend, Arches/Canyonlands, Bryce Canyon, Mesa Verde, and Grand Canyon. In the course of three workshop days, the interpreters were exposed to topnotch presentations by Phil Wondra, chief of the Air and Water Quality Division's research branch, from Bill Malm, senior research scientist on Wondra's staff, and from Darwin Morse, environmental protection specialist with the Division's policy, planning and implementation branch. Morse's presentation was built around a set of 84 "core" slides, which then were used by the workshop participants as the basis for developing their own park-specific interpretive programs.

Following the workshop, interpreters went back to their parks and polished and refined their presentations. The fine programs that have resulted are being presented in parks within the three Regions and have elicited uniformly excellent response from visitors. Even representatives of some of the identified pollution sources have reacted positively and without rancor to the even-handed, factual presentations being made by park interpreters.

In collaboration with editor/writer/interpreter Dan Murphy of the Southwest Region, I put together a slide/tape show that has been presented at several scientific meetings, notably the Southwest and Rocky Mountain section of the AAAS in Lubbock, Texas in March 1984, the May 1984 National Air Quality conference hosted by Mesa Verde NP and focused on the Four Corners (Arizona, New Mexico, Colorado, and Utah) area, and the Oct. 29-Nov. 2, 1984 meeting of the National Atmospheric Deposition Program Technical Committee held in Asheville, NC. As the author of this article, I regret being unable to supply illustrative photos, but as I tell my audiences, "We have nothing to show you but filthy pictures."

In all cases, the reaction has been commendation for the quality of the research and for the willingness of the National Park Service to speak out on an issue of such importance to the protection of air resources in key national parks.

Yarborough is a physical scientist with the Southwest Region of the National Park Service.

letters

To the editor:

John Dalle-Molle's letter in the Summer, 1984 issue of *Park Science* raised several questions concerning the provisions of 36 CFR 2.5, *Research Specimens*, and the rationale behind the recent revision that resulted in stricter standards being applied to the issuance of collecting permits in units of the National Park System. I hope this response will provide your readers a better understanding of the background of the revision of NPS General regulations which took place and clarify the intent of this regulation in particular.

One of the primary objectives established at the beginning of the recent revision of 36 CFR Parts 1, 2, and 3 was, through the regulatory process, to reaffirm the Service's traditional dedication to the protection of park resources. After almost four years in the making, the final product reflects this goal in several ways, the most significant being the elimination of management categories as a consideration in the level of protection afforded resources and the restriction that activities in derogation of park values occur only if authorized by a park's enabling legislation. These two changes are based on provisions of 16 U.S.C. 1a-1 enacted in 1970 and 1978 that emphasize that the various units of the National Park System should be preserved and managed as a system, consistent with the purposes expressed in the NPS Organic Act, and that their protection, management and administration shall not be exercised in derogation of their values and purposes except as specifically provided by Congress. The CFR revisions resulted in these standards being applied not just to situations involving the obvious consumptive use of resources (hunting, trapping, grazing, mining, commercial fishing) which have traditionally been considered contrary to NPS policy; but also to other activities that now have as a prerequisite a determination by the superintendent that they will not adversely affect park resources or be in derogation of park values (termination of closures, issuance of permits, gathering of natural products, issuance of certain collecting permits, removal of downed aircraft).

The current regulations provide superintendents a great deal of discretionary authority through the designation process. However, that authority is limited and cannot be used to relax restrictions imposed by a General Regulation unless specifically provided for by that individual regulation, and cannot be exercised to authorize activities in derogation of park values. When Mr. Dalle-Molle referred to the facts that the regulations impose stricter standards of resource protection and that greater managerial accountability is being required for the protection of resources, he is correct. This strong position, fully supported by the Director, is a direct result of the Congressional mandate expressed in the 1978 amendment to the NPS Organic Act previously mentioned.

Several of the questions Mr. Dalle-Molle raised pertaining specifically to 36 CFR 2.5 have been raised by others. The first point to be emphasized is that none of the restrictions imposed by this section applies to activities conducted by the NPS or its agents pursuant to an approved resource management plan (see 36 CFR 1.2(e)). 36 CFR 2.5 applies only to research proposed by non-NPS individuals or institutions.

Section 2.5(f) prohibits the issuance of a collecting permits for wildlife or fish or plants in park areas whose enabling legislation specifically prohibits the killing of wildlife. The inclusion of fish and plants in this restriction is not only an exercise of discretionary authority to extend a consistent level of protection to all biota, but also reflects the legislation of the 17 park areas affected by this paragraph. Sixteen of these laws, although not all identical, are very similar and patterned after the 1894 amendment to Yellowstone's enabling legislation. All basically prohibit the killing, wounding or capturing of wild animals; provide for the preservation of timber, mineral deposits, natural curiosities and wonderful objects; and require protection of animals, birds and fish. Some contain language relating more specifically to the protection of plants and the prevention of animals from being frightened or driven from the park. Denali National Park's legislation differs, but prohibits the killing of wildlife and provides for the preservation of animals, birds, fish, natural curiosities and scenic beauties. In prohibiting all collecting permits for fish, wildlife, and plants in these park areas, the NPS has taken the position that those values were recognized by Congress as being so significant, that non-essential research involving the killing or taking of such biota should not occur and essential research should be conducted or supervised by the Service.

Although section 2.5(a) does extend the requirement for a permit to the collection of rocks and minerals, that requirement was not repeated in paragraphs (d), (e) and (f). Mr. Dalle-Molle has identified an apparent inconsistency in those paragraphs that may result in different standards of protection being afforded certain park resources. We will definitely review that regulatory language and applicable legislation this fall to see if a revision is appropriate.

Section 2.5 is intended both to set consistent Servicewide standards for reviewing non-NPS proposals to conduct research in park areas and to serve as a guide and tool for managers to use in rejecting invalid or otherwise undesirable proposals. Section 2.5(f) should not be viewed as an obstacle by managers in the 17 park areas (Yellowstone, Sequoia, Yosemite, Mt. Rainier, Crater Lake, Mesa Verde, Denali, Glacier, Rocky Mountain, Hawaii Volcanoes, Lassen Volcanic, Shenandoah, Great Smoky Mountains, Mammoth Cave, Isle Royale, Olympic and Haleakala National Parks) affected by that paragraph. Non-NPS research proposals which they consider legitimate and that meet the objectives of NPS resource management plans may still be carried out through a contract, agreement or other administrative mechanism that makes the researcher an agent. Such an arrangement also gives the manager an appropriate degree of control over research techniques and methodology, if so desired, and qualifies the research as an adminstrative activity of the Service. Such action satisifes the requirement of section 1.2(e) and exempts the research from provisions of the regulations in Parts 2 through 7.

I encourage those of your readers who have not done so recently, to read 16 U.S.C. 1a-1 and become familiar with the legislation that generated this overall effort by the Service to achieve a more consistent approach to the protection of park resources and values. For those who wish to learn more about the intent and rationale behind the revision of the General Regulations, I suggest reading the preambles to the proposed and final rules published in the Federal Register of March 17, 1982 (47 FR 11598), June 30, 1983 (48 FR 30252), December 27, 1983 (48 FR 56971), and April 30, 1984 (49 FR 18442).

Stanley T. Albright
Associate Director, Park Operations

Integrated Planning For Resource Uses Is Workshop Focus

An intensive three-week Coastal Zone Management workshop for the training of trainers will be held in Bangkok, Thailand beginning the second week in March, 1985, under the auspices of the NPS Office of International Park Affairs, (IPA) according to Hugh Muller, program manager.

Joanne Michalovic, one of two NPS permanent staff members in the Washington IPA office, will participate in the workshop in Thailand. Dan Creeden, a former chief of training for AID (Agency for International Development), is acting as consultant on the project, through a cooperative agreement between NPS and the International Union for Conservation of Nature and Natural Resources (IUCN).

Jeff Tschirley, the other permanent NPS staff member on the project, in December attended with Michalovic an Arizona meeting with range management experts to plan a similar workshop on Arid and Semi-Arid Range Management for three weeks in June 1985 at Harare, Zimbabwe.

The two workshops are part of the NPS/AID Expanded Information Base Project now underway, intended to disseminate resource management information to developing countries. The project takes an integrated planning approach to design and implementation of development processes, incorporating the sociological processes (economic, institutional, regulatory, etc.) within the framework of the natural ecological systems.

Workshop attendees will range from students and professors to planners and government officials. The focus will put both the basic natural resource picture and the social/governmental picture into a single context, within which the workshop can seek ways of arriving at the best management plans that have a realistic chance of being carried out under a given set of social and governmental circumstances.

A fuller story on this project will be carried in the Spring issue of *Park Science*.

Social Indicators Explored For Biophysical Monitoring

Gary Machlis and Gerald Wright of the NPS/CPSU at the University of Idaho, are co-authors of a paper on the use of social indicators as a less costly alternative technique for monitoring biophysical changes in world biosphere reserves. The paper appears in *The Biosphere: Problems and Solutions*, edited by T.M. Veziroglu and published in 1984 by Elsevier Science Publishers B.V., of Amsterdam, The Netherlands. Several indicators of Olympic National Park Biosphere Reserve are developed to illustrate the potential of such a technique.

People, Animals, Parks

A working bibliography entitled "People, Human Behavior, and Animals in Parks and Preserves" has been published by the NPS/CPSU at Oregon State University as CPSU/OSU 84-11 – the work of Martha E. Lee, Donald R. Field, and Kent Schwarzkopf. The 35-page publication represents a continuing interest of the staff and students in the OSU College of Forestry and will be updated on an annual basis.

Natural Resource Trainee Program FY 1984-85

By Susan P. Bratton and Carol Bickley

The new Natural Resource Specialist Trainee Program began Dec. 3, 1984, at Clemson University, with orientation and a course in situational leadership followed by a week-long introduction to microcomputers. Each of the 23 trainees will receive a Televideo microcomputer for use during the 22-month training program. The trainees will participate in a coordinated series of courses taught mostly by NPS staff and/or university faculty. These courses will not only emphasize key areas of resource management such as wildlife population ecology and aquatic systems, but also will encourage "hands-on" learning of resource skills, including microcomputer use. Many of the courses will include field trips to park areas and laboratory exercises that investigate actual park problems.

Unlike the previous natural resource training program, the new program will be more academically structured with common courses and activities for all of the trainees as a group. Dr. Richard Briceland, Associate Director for Natural Resources, and his staff will oversee the academic elements of the program. The program also will involve the use of training park or regional offices where supervisors are available who already are skilled resource managers, and the selection of "on-site" counselors to advise the trainees and to act as mentors. These counselors will help the trainees construct Individual Development Plans and will supervise on-the-job training activities. The counselors also will consult with the superintendents or other resource staff of the destination park or region to try to identify the needs of the destination site that should be included in the training program.

Among the courses the trainees will be taking are: microcomputer skills, air quality, pest management, geographic information systems, techniques of wildlife management, wildlife population ecology, mining and minerals, water resources, fisheries and aquatic systems, coastal processes, vegetation management, natural resource law, cultural resources, fire ecology, recreation sociology, situational leadership, planning and budgeting, conflict resolution, and professional ethics.

Among the sites where the courses will be offered are the Denver Service Center, the EROS Center in Sioux Falls, Oregon State University, Colorado State University, Colorado School of Mines, Rutgers University, Clemson University and University of California at Davis.

Each trainee will be expected to carry out an individual project at the training site, and must complete all necessary planning tasks for this project, as well as field execution and a final report. Upon finishing the program in September 1986, each trainee will have had a wide variety of experiences in resource management, will have gained broad knowledge, and will have developed the professional skills necessary to accomplish resource management project goals.

Bratton is a Research Scientist for NPS at the University of Georgia Institute of Ecology; Bickley is Program Coordinator, Office of Natural Resources, WASO.

NATURAL RESOURCE TRAINING PROGRAM
Training and Destination Locations

No. of Positions	Region	Training Location	Destination Location
2	Alaska	Alaska Regional Office Alaska Regional Office	Bering Land Bridge Nat'l Pres. Katmai NP/Aniakchak NM
3	Mid-Atlantic	Gettysburg Nat'l Mil. Park Delaware Water Gap NRA Shenandoah NP	Fredericksburg Nat'l Mil. Park Upper Delaware Scenic & Rec. River Valley Forge NP
3	Midwest	Indiana Dunes Nat'l Lakeshore Isle Royale NP Ozark Nat'l Scenic Riverways	Scotts Bluff NM Apostle Island Nat'l Lakeshore St. Croix Nat'l Scenic Riverway
2	North Atlantic	North Atlantic Reg. Office Fire Island NS	Saratoga NHP/St. Gaudens NHS/ Ft. Stanwix NM Roosevelt-Vanderbilt/ Martin Van Buren NHS
2	National Capital	Nat'l Capital Parks – East Rock Creek Park	Manassas Nat'l Battlefield Park Nat'l Capital Parks – East
3	Pacific Northwest	Pac. Northwest Reg. Office Mt. Rainier NP Mt. Rainier NP	Crater Lake NP Olympic NP Pac. Northwest Reg. Office
2	Rocky Mountain	Yellowstone NP Dinosaur NM	Badlands NP Grant Teton NP
2	Southeast	Everglades NP Everglades NP	Southeast Regional Office Cumberland Islands NS
2	Southwest	Southwest Regional Office Southwest Regional Office	Carlsbad Caverns/ Guadalupe Mtns. NP Chickasaw NRA
2	Western	Hawaii Volcanoes NP Sequoia/Kings Canyon NP	Haleakala NP Lake Mead NRA

NATURAL RESOURCE SPECIALIST TRAINEES

Trainee (Current Duty-Station)	Training Location	Destination Location
Richard Harris (Padre Island NS)	Alaska RO	Bering Land Bridge NP
David Manski (NCR)	Alaska RO	Katmai NM/Aniakchak NM & P
Douglas Wallner (Sequoia/Kings Canyon NP)	Gettysburg NMP	Fred. and Spotsylvania County Battlefield Memorial NMP
Margaret Weesner (Joshua Tree NM)	Delaware Water Gap NRA	Upper Dela. Scenic & Rec. R.
Brian Lambert (Delaware Water Gap NRA)	Shenandoah NP	Valley Forge NHP
George Oviatt (GW Carver NM)	Indiana Dunes Nat'l Lakeshore	Scotts Bluff NM
Janis Meldrum (Isle Royale NP)	Isle Royale NP	Apostle Islands NL
Victoria Mendiola (Whiskeytown NRA)	Ozark National Scenic Riverways	St. Croix National Riverway
Robert Cook (Gateway NRA)	North Atlantic RO	Saratoga NHP
Patrick Lynch (George Wash. MP)	Fire Island NS	Roosevelt-Vanderbilt/Martin Van Buren NHS
Jenness Hall (Prince William Forest Park)	National Capital Parks – East	Manassas National Battlefield Park
Stephen Syphax (NCR)	Rock Creek Park	National Capital Parks – E.
James Milestone (Golden Gate NRA)	Pacific NW RO	Crater Lake NP
Catherine Hawkins (Mt. Rainier NP)	Mt. Rainier NP	Olympic NP
Janet Edwards (Santa Monica Mountains NRA)	Mt. Rainier NP	Pacific NW RO
Susan Consolo (Yellowstone NP)	Yellowstone NP	Badlands NP
Mark Schroeder (Redwood NP)	Dinosaur NM	Grand Teton NP
George Gregory (Mammoth Cave NP)	Everglades NP	Southeast RO
Russell Galipeau (Canaveral NS)	Everglades NP	Cumberland Islands NS
Vidal Davila (Big Bend NP)	Southwest RO	Carlsbad Caverns/Guadalupe Mountains NP
Jennifer Bjork (Biscayne NP)	Southwest RO	Chickasaw NRA
William Brock (Great Smoky Mtns. NP)	Hawaii Volcanoes NP	Haleakala NP
Michael Coffe (Sequoia/Kings Canyon NP)	Sequoia/Kings Canyon NP	Lake Mead NRA

Yellowstone Ecosystem

By Franz J. Camenzind

Editor's Note: The following paper was written for the Greater Yellowstone Coalition, 40 E. Main, Bozeman, MT 59715, and submitted to Park Science *by Coalition Director Robert Anderson.* Park Science *editorial board members enthusiastically favored publication of the Camenzind article, with special attention to its usefulness as source material and as a model for interpretation at Yellowstone and others of the great natural National Parks.*

By Franz J. Camenzind

In the past 20 years the words **ecology** and **ecosystem** have entered nearly everyone's vocabulary and yet attempts to define and apply them to specific areas often end in confusion. **Ecology** literally means the study of the "house" or place where a plant or animal lives (habitat or environment), and **ecosystem** refers to the workings (interrelationships) of all the parts of the "house" (Odum 1971, Whittaker 1970).

Outlining the boundary of any ecosystem is difficult (Evans 1965). In the broadest sense, everything around us plays a part in our lives and it is appropriate to think of the entire planet (ecosphere) as our **environment** and **ecosystem.** This serves to place human beings' position on this planet into proper perspective, but it does not provide us with a politically manageable entity. The area of immediate concern must be reduced to something with tangible boundaries, clearly defined elements and, for our psychological benefit, it must be discrete enough to enable us to think that we can significantly affect its intrinsic ecological interrelationships.

Ecologists have tackled this problem by dividing the **ecosphere** into smaller components. For example, all living things appear as species, all species exist as populations, and all populations of closely interacting species constitute a community. The community interacting with the nonliving components in its **environment** constitute the **ecosystem** (Kormondy 1969, Whittaker 1970).

This approach provides a conceptual definition of an **ecosystem** but problems still exist when the idea is transported from our minds to a geographical location. Where on earth should these boundaries be placed? And where are the components of neighboring **ecosystems** sufficiently dissimilar to form an **ecotone** (ecosystem boundary)?

For example, the survival of many birds that summer in the Greater Yellowstone Region depends upon environmental conditions in the southern states and perhaps all through Central and South America; terrestrial and aquatic habitats and the animals that depend upon them may be altered by acid rain originating far outside the region. Clearly, the summer and winter habitats of the migratory birds are extremely dissimilar and widely separated and yet the species require both to survive. Should these remote winter ranges and the distant industrial sites be considered in the Greater Yellowstone Ecosystem management plan? Ecologically, the answer should be yes, but from practical and political standpoints, they may have to be ignored.

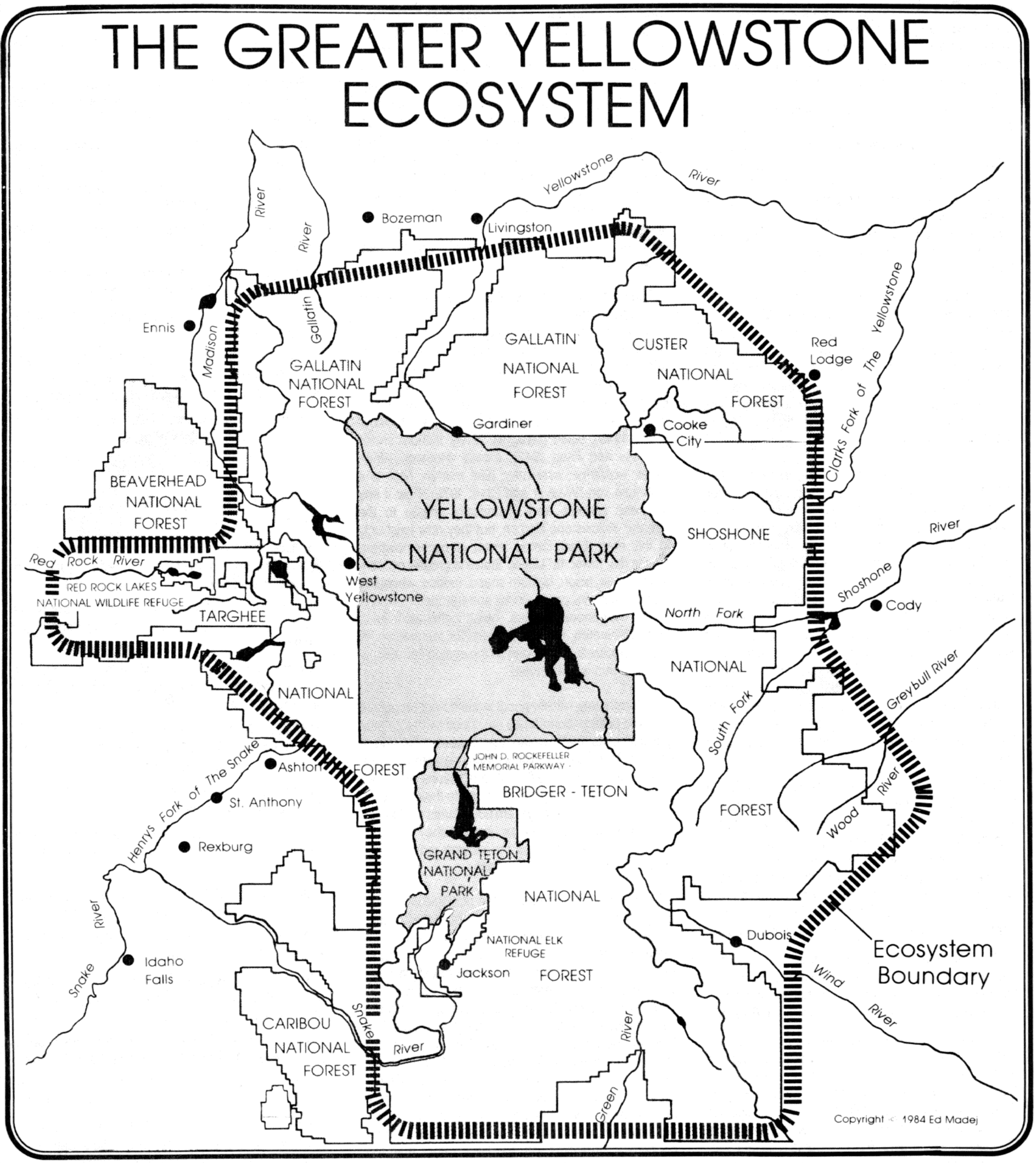
To come to grips with this problem, we must remember that the **ecosphere** is made up of all living and nonliving components interrelating with one another. The nonliving elements are relatively easy to comprehend and evaluate when compared to the living components, which vary far more over time (evolutionary changes) and space (local adaptations to different environmental conditions). The key concept involves the number and types of **interrelationships** (Kormondy 1969). Biologists and ecologists consider genetic exchange within a population and between adjacent populations of a species to be one of the most important **interrelationships** in nature (Emmel 1976). Genetic variability, which is potentially greatest within large gene pools, enables a species to adapt to changes in the living and nonliving components of its environment. Genetic variability is essential to species survival in the ever-changing **environment** (Ehrlich and Ehrlich 1981).

For our purpose we will view the area of northwestern Wyoming, southwestern Montana, and eastern Idaho at two levels: first the Greater Yellowstone Region, second the Greater Yellowstone Ecosystem.

The Greater Yellowstone Region consists of approximately 18 million acres of wild and semi-wild land characterized by environmental similarity and geographic continuity. Within it lie the headwaters of the Missouri (Mississippi), Snake (Columbia), and Green (Colorado) rivers. It includes Yellowstone and Grand Teton national parks and all or parts of the Bridger-Teton, Shoshone, Targhee, Gallatin, and Custer national forests. It also includes the National Elk Refuge, Red Rocks Lake National Wildlife Refuge, Harriman State Park (Idaho), and numerous parcels of state and private lands. In all, over 25 different political units overlap the area of the Greater Yellowstone Region, each with different jurisdictions and each with different ideas as to how best to utilize and manage the unique natural resources of the area.

Topographically, the Greater Yellowstone Region is comprised of several mainly north-south oriented mountain ranges and the high plateau of Yellowstone National Park. The region is bounded by the Madison and Gallatin ranges on the northwest; the Beartooth Mountains on the north and northeast; the Absaroka Range on the east; the Wind River Range on the southeast; the Gros Ventre Range, Grayback Ridge, and the Snake River Range on the south and south-

LANDSAT-1 satellite scene *shown here covers most of the greater Yellowstone ecosystem. The image was obtained Nov. 23, 1972 in the photographic infrared portion of the electromagnetic spectrum (MSS channel 7). This type of data is used by the NPS as a tool for inventorying and managing park resources via digital image processing and computerized geographic information systems (GIS).*



***Boundary clashes** are inherent in the situation illustrated here – the Greater Yellowstone Ecosystem (shown in railroad-tie outline) enclosing or crossing the borders of more than two dozen political entities that fall within the Greater Yellowstone Region. The Region, shown here as backdrop for the ecosystem, consists of approximately 18 million acres of wild and semi-wild land, characterized by environmental similarity and geographic continuity.*

Yellowstone Ecosystem

Continued from page 12

west; and the Teton Range, Yellowstone Plateau, and Centennial Range on the west. Included are adjacent foothills and lowlands that provide essential winter range for ungulate species that seasonally occupy the higher, mountainous core of the region.

At the core of the Greater Yellowstone Region lies the Greater Yellowstone Ecosystem. From a practical standpoint, an **ecosystem** is an area that functions largely as a self-contained, natural unit, requiring little more than air, water, and radiant energy from outside its boundaries to exist in perpetuity. The core of the Greater Yellowstone Region approximates such an **ecosystem;** within it occur most of the components present when the area was first discovered by the furtrappers and explorers 150 years ago.

The major topographic features of the Greater Yellowstone Region are relatively young. Most of the surface of Yellowstone National Park was formed by volcanic action approximately two million years ago and by more recent glaciation (Sutton and Sutton 1972). Much of the Teton Wilderness and the Absaroka Range are covered by material from this and earlier volcanic activity (Smith and Peltan 1979, Smith and Christiansen 1980).

The Teton Range is an uplifted, fault block mountain range of relatively recent origin (less than 10 million years ago). The gneiss and schist which form the mountains are approximately 2.5 billion years old and very resistant to erosion. This, coupled with the short time they have been exposed to erosion and sculpturing by glaciers accounts for their rugged and sharp features (Love 1968). The most recent major geologic influences upon the land immediately east of the Teton Range (Jackson Hole) were the glaciers which swept south out of the Yellowstone highlands as recently as 15 thousand years ago. These glaciers deposited layer upon layer of finely ground mineral material throughout the valleys and left moraines and lakes as they retreated; consequently, the soils of much of this region are young and poorly developed (Love 1968).

The origin of the Wind River Range is similar to that of the Tetons, but much older (perhaps 50 million years old). The Gros Ventre Range, Grayback Ridge, and the Snake River Range are all of sedimentary origin. The Gros Ventres have been uplifted and moderately folded, while Grayback Ridge and the Snake River Range have undergone extensive folding and thrusting, forming the Overthrust Belt (Blackstone 1971), which has potential for oil and gas production.

These and many other physicial features have influenced the plant and animal communities as well as the mineral wealth and subsequent human and industrial development of the Greater Yellowstone Region.

Situated as it is at the headwaters of three of our nation's major river systems, it is not surprising that at least seven floras of quite distinct compositions and histories coalesce in the Greater Yellowstone Region. A southern Rocky Mountain flora includes species such as Englemann spruce, Colorado blue spruce, Douglas fir, limber pine, Rocky Mountain juniper, narrowleaf cottonwood, green gentian, and Parry's primrose. There are more members of the Pacific Northwest flora (Sitka-Oregonian flora (Taktajan 1978, Cronquist 1982)) such as beargrass, false huckleberry, shootingstar and Sitka alder. Prominent members of the Great Basin flora include several sagebrush species, antelope bitterbrush, winterfat, mountain mahogany and balsamroot. Northern Rocky Mountain floral elements include lodgepole pine, subalpine fir and whitebark pine as well as western mountain ash and Scouler willow. The Boreal North American floral elements include white spruce, prostrate juniper, balsam poplar, quaking aspen and one-flowered wintergreen. In addition, two more or less circumpolar floras are represented: the boreal (dwarf juniper, tufted hairgrass, kinnikinnick, fringed sagebrush and white wintergreen) and arctic-alpine (Dorn 1977, Booth 1966, Davis 1952, Hitchcock and Cronquist 1973).

The combination of diverse plant communities, rugged topography, high altitude, and remote location has enabled the Greater Yellowstone Region to maintain a diverse and relatively intact fauna. Some of the species key to the region include the bald eagle, osprey, peregrine falcon, great gray owl, whooping crane (Dorn 1979), trumpeter swan (Banko 1960), grizzly bear (Craighead 1979), blackfooted ferret (Clark 1983), bison (Meagher 1973), bighorn sheep (Honess and Frost 1942), moose (Houston 1968), fisher, wolverine, river otter, pine marten, lynx, and mountain lion (Weaver and Clark 1979). Few if any of these species were historically unique to the Greater Yellowstone Region, but they now exist only in this area (black-footed ferret) or occur nowhere else in the "lower 48" United States in greater concentrations (elk, bison, bighorn sheep, moose, whooping cranes (summer populations) and trumpeter swans). Some indigenous species, notably the wolf, have been eliminated, but the potential for restorations of these species exists so long as the ecological integrity of the region is maintained.

Unfortunately, wildlife populations do not recognize the bold political boundaries described by the 25-plus political units that overlap the Greater Yellowstone Region. Many species, particularly ungulates, require areas within several different jurisdictions and even some far removed regions to complete their life cycle. Consequently, the **ecosystem** boundaries seldom follow the political boundaries; instead they are constantly being redefined by the varying requirements of the diverse wildlife populations.

Because our knowledge of the ecological requirements of many of the species present in the Greater Yellowstone Region is incomplete, the boundaries for the **ecosystem** must remain vague. The most important point to remember is that an **ecosystem** must contain all the elements required to perpetuate all species indigenous to the area. In this case, only the habitats located within the Greater Yellowstone Region will be considered as part of the Greater Yellowstone Ecosystem. Our larger area of concern, the Greater Yellowstone Region, can be more specifically, although somewhat arbitrarily, defined by including all lands ecologically similar and geographically contiguous. If we err, we must err in favor of the resource by concerning ourselves with too large rather than too small a region.

LITERATURE CITED

Banko, W. 1960. *The trumpeter swan.* USDI-FW. Fauna Ser. No. 63.

Blackstone, D. 1971. *Traveler's guide to the geology of Wyoming.* Geo. Sur. of Wyoming. *Bull. 55.* Laramie, Wyoming.

Booth, W. 1966. (2nd ed.). *Flora of Montana.* Bozeman, Montana.

Clark, T. 1983. *Last of the black-footed ferrets?* Nat. Geo. Mag. 163(6):828-838.

Craighead, F. 1979. *Track of the grizzly.* Sierra Club Books, San Francisco.

Cronquist, A. 1982. *Map of the floristic provinces of North America.* Brittania 34(2):144-5.

Davis, R. 1952. *Flora of Idaho.* W.C. Brown, Dubuque, Iowa.

Dorn, R. 1979. *Vascular plants.* p. 7-42. In: Clark, T. and R. Dorn (eds.). Rare and endangered vascular plants and vertebrates of Wyoming. Jackson, Wyoming.

Dorn, R. 1977. *Manual of the vascular plants of Wyoming.* 2 vols. Garland Publ. Co., N.Y.

Ehrlich, P. and A. Ehrlich. 1981. *Extinction.* Random House, N.Y.

Emmel, T. 1976. *Population biology.* Harper and Row, N.Y.

Evans, F. 1965. *Ecosystems as the basic unit in ecology.* p. 166-7 In: Kormondy, E. (ed.). Readings in ecology. Prentice-Hall, Inc., Englewood, N.J.

Hitchcock, C. and A. Cronquist. 1973. *Flora of the Pacific Northwest.* University of Washington Press, Seattle.

Honess, R. and N. Frost. 1942. *A Wyoming bighorn sheep study.* Wyo. Game and Fish Dept. Bull. No. 1. Cheyenne, Wyoming.

Houston, D. 1968. *The Shiras Moose in Jackson Hole, Wyoming.* Grand Teton Nat. Hist. Assoc. Tech. Bull. No. 1. Jackson, Wyoming.

Kormondy, E. 1969. *Concepts in ecology.* Prentice-Hall. Inc. Englewood, N.J.

Love, J. and J. Reed. 1968. *Creation of the Teton Landscape.* Grand Teton Nat. Hist. Assoc. Moose, Wyoming.

Meagher, M. 1973. *The bison of Yellowstone National Park.* Nat. Park Ser. Sci. Mon. Ser. No. 1.

Odum, E. 1971. *Fundamentals of ecology.* W. B. Saunders, Co., Philadelphia.

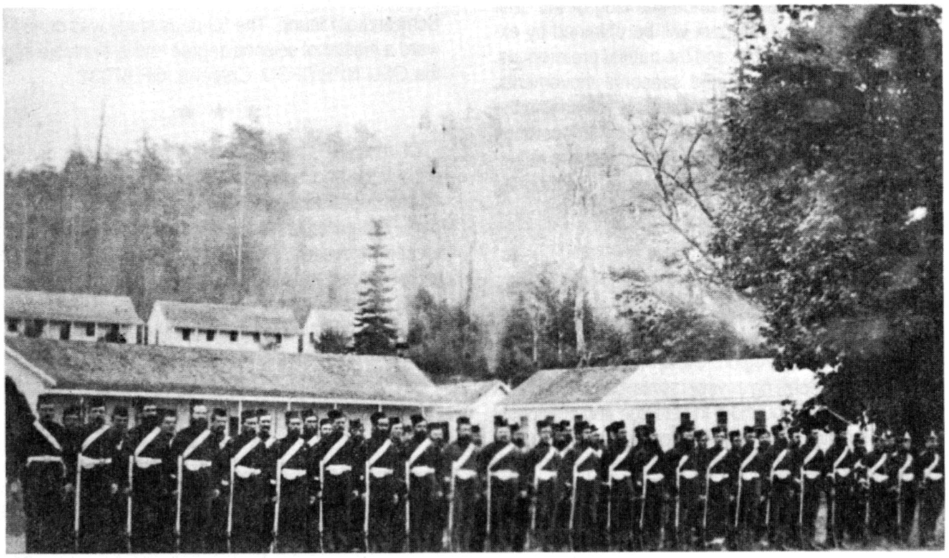
Smith, R. and R. Christiansen. 1980. *Yellowstone is a "hot spot" on the earth's crust.* Sci. Am. 242(2):104-117.

Smith, R. and J. Peltan. 1979. *Recent crustal uplift in Yellowstone National Park.* Science 206:1179-1182.

Sutton, A. and M. Sutton. 1972. *Yellowstone: A century of the wilderness idea.* Chanticleer Press, N.Y.

Weaver, J. and T. Clark. 1979. *Mammals.* p. 63-76. In: Clark, T. and R. Dorn (eds.). Rare and endangered vascular plants and vertebrates of Wyoming.

Whittaker, R. 1970. *Communities and ecosystems.* The Macmillan Co., London.



This 1860s photo *of the English Royal Marines on English Camp parade ground at San Juan Island (now a National Historic Park) in the Puget Sound area of Washington, preserves for posterity the individuality of the soldier on the left with his sash on backwards and the fact that certain trees still alive were well established in the 1860s.*

In 1984 at San Juan Island, *young trees are growing on both sides of a rabbit exclosure fence – part of a team research project described in the Fall issue of* Park Science *by James K. Agee, aimed at understanding the ecosystem operation, the rabbit population decline, and the historic landscape and restoration options at San Juan Island. The bushy trees are lodgepole pines, the thinner-branched trees are Douglas firs. Natural regeneration declines rapidly as the distance from the forest edge increases.*

Craters of the Moon Plant Communities

By R. Gerald Wright and Thomas A. Day, Cooperative Park Studies Unit, University of Idaho, Moscow, Idaho

The CPSU at the University of Idaho recently completed a two-year study that described and mapped the vegetation at Craters of the Moon National Monument. The project was carried out using a combination of field sampling methods and by manually interpreting 1:1500 scale color aerial photos. Vegetation types were delineated based on the most dominant and conspicuous species and on those species having high reflective cover within an area.

Although it may come as a surprise to those individuals who have only briefly visited the monument, the 21,650 ha area has a unique and highly diverse flora. Because much of the southern two-thirds of the monument is isolated from other vegetated areas by barren lava flows and receives low levels of backcountry use, the plant communities were found to be essentially free of disturbance. In addition, because of the time since the last volcanic eruptions (about 2200 years) and the general absence of fire, most of this vegetation appears to be in a climax or near-climax stage.

A total of 26 vegetation types was identified and mapped. The map was rectified to a scale of 1:24,000 and photographically combined with the new park topographic map of the same scale.

Flows of a'a, pahoehoe, and black lava, which have low plant cover, dominate much of the monument (68%). A variety of forbs combined with tansybush *(Chameabatiaria millefolium),* mountain big sagebrush *(Artemisia tridentata* ssp. *vaseyana)* and rubber rabbitbrush *(Chrysothamnus nauseosus)* make up the vegetative cover on these flows. Other large areas of the monument are more densely covered by a variety of shrub dominated communities. There the principal shrubs are antelope bitterbrush *(Purshia tridentata),* wax current *(Ribes cereum),* mountain big sagebrush, and rubber rabbitbrush found in combination with several species of perennial grasses, of which bluebunch wheatgrass *(Agropyron spicatum)* is most common. These shrub communities provide excellent spring and early summer browse for mule deer. Limber pine *(Pinus flexilus)* also is found throughout many of these communities.

Although they make up only a small part of the monument (2%), the cinder gardens are one of the unique plant communities. They are found primarily on and adjacent to the cinder cones where growing conditions are extremely harsh due to summertime high soil surface temperatures (often exceeding 160°F) and low soil moisture levels. These areas are dominated by small perennial forbs such as dwarf buckwheat *(Eriogonum ovalifolium* var *depressum)* and dwarf monkeyflower *(Mimulus nanus).*

Equally small in extent, but giving evidence to the vegetative diversity, are the Douglas fir communities at the higher elevations on north-facing slopes and the quaking aspen stands on the upland sites. A report on the study "The vegetation types of Craters of the Moon National Monument" by Thomas A. Day and R. Gerald Wright, number B 84-2, is available from the University of Idaho CPSU, Moscow 83843.

regional highlights

WASO

In FY 1985, 62 projects have been chosen for total funding of approximately $7 million. Top ranking was given the water quality research and monitoring effort now in its third year at Crater Lake. Of the 62 projects, 11 are new, chosen from a list of 404 submitted by the Regions. The regional representatives, who met in October and made the selections, also set up an SRP multi-year project file for future use in allocating the Natural Resource Preservation Program Account.

★ ★ ★

The Integrated Pest Management (IPM) program is undergoing review, preparatory to another IPM environmental assessment (for 1986 to 1990) that must be prepared in 1985. The Regions are being asked to review their pest management needs and to advise WASO on their ideas for administering the program. Comments on at least three options are being solicited: (1) continue the program coordination from WASO, (2) maintain present form but with a stated objective of delegating pesticide approval and application certification programs to the field within two or three years, and (3) transfer these programs to the field immediately.

★ ★ ★

NPS and the Bureau of Land Management have signed a Memorandum of Understanding governing control and management of grazing activities on NPS lands. A copy went to each Regional Director on Nov. 15, 1984. The MOU makes clear that "NPS is responsible for the administration of grazing on all units of the System except Glen Canyon NRA . . . (and) will administer grazing programs in units of the System in accordance with its grazing regulations currently codified in 36 CFR S2.60."

North Atlantic Region

The Appalachian Mountain Club has been selected to conduct a five-year study of visitor use and impact patterns on Isle au Haut in Acadia NP. The NPS is required by statute to establish visitor carrying capacities for Isle au Haut, which will assure negligible adverse impacts on the island's natural resources, conserve the character of the island's small village, and protect the quality of the park visitor's experience. AMC will determine the amount and pattern of visitor use on Isle au Haut and will measure the rate at which any degradation of natural resources is occurring. They will then determine the level of visitation above which the ecosystems on the island would be unable to return to a condition within their natural range of variation during the next visitor season. The level of visitation thus identified will be used as the carrying capacity for Isle au Haut.

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SUNY/Syracuse has begun a five-year study on the interactions between white-tailed deer and vegetation within Saratoga NHP. The principal thrust of this research will be to determine impacts of deer on vegetation succession in areas of the park that now are old fields or shrubland, but which were forests in 1777, and to suggest measures which might be considered to mitigate these impacts.

In addition, a thorough understanding of the deer herd in and around the park will be obtained by examining deer food habits and the habitat preferences, behavior patterns, daily and seasonal movements, and population dynamics. These data will enable the park to manage the local deer herd, in cooperation with the State of New York, and should result in reduction in the damage caused by deer on neighboring farms and orchards.

★ ★ ★

Steve Maddock has joined the NAR Office of Scientific Studies and is responsible for deer studies, visitor impact studies, and the National Natural Landmark program within the region. Steve has spent the past eight years performing environmental compliance and planning duties throughout the Region and previously worked for the US Forest Service as Project Leader of the Cooperative Outdoor Recreation Research Unit at North Carolina State University. His Ph.D. in conservation and resources management is from the University of Michigan. Maddock has held positions with the Soil Conservation Service, USDA; School of Forestry, North Carolina State University; and the Appalachian Mountain Club, Boston, MA.

★ ★ ★

A Cooperative Agreement was signed this year with the University of Massachusetts for development of a general research program related to vegetation and fire ecology and fire-wildlife interactions. Six projects were initiated under this agreement in FY 84. These include: (1) an investigation of the use of fire to maintain historic, open fields of Saratoga National Historical Park; (2) an investigation of the effects of mowing and burning on the reproduction of huckleberry *(Gaylussocia boccata)*; (3) a white-tailed deer management study at Morristown National Historic Site; (4) a white-tailed deer management study at Fire Island National Seashore; (5) the development of a fire management plan at Acadia NP; and (6) a "pulse study" at Roosevelt-Vanderbilt NHS.

★ ★ ★

Peregrine falcons were reintroduced to Acadia NP this year under a Cooperative Agreement with the College of the Atlantic. This program will continue for at least the next four years.

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Jim Allen has been involved with numerous studies to define causes and feasible managerial solutions to regional coastal problems of both natural and man-induced beach/dune erosion, inlet dynamics, bar-beach interaction, ORV impacts, nearshore sediment transport, and shoreline changes at CACO, FIIS, and GATE. Through the Barrier Island Significant Resource Problems, Dr. Allen's "geographic" training also has been utilized in "bi-regional" chores at San Juan NHS (El Morro), Canaveral NS, DeSoto NM, Gulf Islands NS, a MAB evaluation, and at Assateague NS.

Pacific Northwest Region

"Feeding of Golden-Mantled Ground Squirrels by Park Visitors at Crater Lake National Park" is the title of NPS/CPSU publication No. 84-9 from the Oregon State University Cooperative Park Studies Unit. S. Kent Schwarzkopf, author, describes the interaction between the squirrels and park visitors at a highly visited portion of Crater Lake's Rim Village area. Signs stressing the danger to humans of bubonic plague were twice as effective in deterring feeding as those emphasizing the welfare of the squirrels, Schwarzkopf found. The 52-page study was done toward a master of science degree and is available from the OSU NPS/CPSU, Corvallis, OR 97331.

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Olympic NP, on Dec. 18, 1984, hosted a conference/workshop on local research related to atmospheric deposition/acidification studies in or near the park. The purpose was fourfold: 1) to provide a forum for sharing research results and plans; 2) to meet with investigators and discuss and coordinate research sites, methods, plans, etc.; 3) to obtain a written progress report within one month of the conference, and 4) to provide park managers and interested individuals with an opportunity to learn about acid precipitation research in the park.

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Plans are being worked out with the USFS to produce cooperatively a regional brochure explaining the mission and management objectives of both agencies. It will locate and describe national parks and forests in Washington, Oregon, and Idaho. Publication target date is May 15, 1985. The brochure is designed to provide a comprehensive quick response to written and walk-in requests for recreation resource information at joint information offices and regional offices, as well as at visitor contact stations.

Western Region

A 93-page Annual Report, No. 8, is available now from the NPS Cooperative Park Studies Unit, Institute of Ecology, University of California at Davis 95616. Report No. 8 represents the first time that research activities at the Davis campus CPSU have been reported on a calendar year basis. Formerly, research in California and CPSU activities in California were reported each year in June and December. The report summarizes CPSU activities, researched by NPS research scientists and by investigators on NPS contract, and project titles and investigators for independent (non-NPS funded) research and study projects conducted within the California National Parks served by the Davis CPSU.

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"Living in the Chaparral: An Integrated Approach to Public Safety and Enjoyment" is the title of a symposium and public workshop held Oct. 20, 1984, at the Los Angeles County Museum of Natural History. The all-day workshop, for homeowners and residents of the wildland/urban interface "who want to live more safely in the chaparral environment and who want to protect themselves more effectively from natural or manmade disasters," was co-sponsored by the National Park Service and the National Foundation for Environmental Safety.

Among the more than 20 experts who addressed or moderated conference sessions were Daniel R. Kuehn, Superintendent of Santa Monica Mountains NRA, and his Resource Manager, Kheryn Klubnikin.

★ ★ ★

During FY 85 Western Region will sponsor and co-host three Interregional Resources Management/Interpretation Workshops. These training workshops will focus on the mutual ecosystem/resource management concerns that "cross over" regional boundaries. A primary emphasis will be how park interpretation can be more effective in providing for public understanding and support for park research and resources management programs. Participants will include park managers, research scientists, resources management specialists and park interpreters. There will also be participants from State parks, other Federal agencies, universities, and conservation organizations.

The three workshops will be: Pacific Coastal Parks, Southwest Desert Parks, and Pacific Mountain Parks. The first workshop (Pacific Coastal Parks) will be held February 11-15, 1985, at Santa Monica Mountains National Recreation Area. Parks from Western, Pacific Northwest, and Alaska Regions will participate. For more information contact: Dick Cunningham, Regional Chief of Interpretation, Western Region, (415) 556-3184.

Midwest Region

Norman Hellmers, superintendent at Lincoln Boyhood National Memorial, Lincoln City, Neb., writes of the highly successful symposium on "Restoration Ecology: Theory and Practice" presented recently at the University of Wisconsin's Madison Arboretum. "I found it of great benefit to attend," Hellmers writes, and suggests that *Park Science* once again call attention to the Madison Arboretum's twice-a-year publication, *Restoration & Management Notes,* "a forum for the exchange of news, views, and information among ecologists, land reclamationists, managers of parks, preserves, and rights-of-way, naturalists, engineers, landscape architects, and others committed to the restoration and wise stewardship of plant and animal communities." Editor is William R. Jordan, III, Journals Division, 114 N. Murray St., Madison, WI 53715.

Water Resources Branch

The Water Resources Branch (WRB) in Fort Collins, Colo., has completed a study in Rocky Mountain NP that examines the relationship between backcountry use and possible contamination by *Giardia lamblia* in two watersheds that are popular with recreationists. A cooperative effort involving personnel from Rocky Mountain NP, Colorado State University, and WRB, the study uses several techniques, including 1) sampling water for bacteria, 2) collecting wildlife scat and analyzing it for *Giardia* cysts, 3) pumping stream water to determine the presence of *Giardia* cysts, and 4) interviewing hikers, backpackers and other recreationists to determine use patterns and to discover whether those drinking untreated water from streams in the study area were becoming ill. A final project report is being prepared and will be available from the Branch in early 1985.

Technical reports describing previous projects as well as other scientific information useful for management, preservation, and protection of NPS waters are available through WRB. Reports currently in stock are:

Status Report: Acid Rain Research in the National Park Service, 1982. Tech. Rep. 82-1.

Guidelines for Water Quality Program Developments in National Park Service Areas. Tech. Rep. 82-2.

State of the Art in Road Salt Deicing, 1982. Tech. Rep. 82-3.

Water Management in Park and Recreation Areas. Tech. Rep. 82-5.

Summary of Geologic Factors That May Influence the Sensitivity of Selected Watersheds in Rocky Mountain National Park, Colorado, to Atmospheric Deposition. Tech. Rep. 82-6.

Automatic Water Samplers for Field Use. Tech. Rep. 83-1.

Metal Concentrations in Fish at Curecanti National Recreation Area, Gunnison, Colorado. Tech. Rep. 83-3P

Stream Discharge Rating Curves for the Fall River, Rocky Mountain National Park. Tech. Rep. 83-5P.

Bed Material Analysis on the Fall River. Tech. Rep. 83-6P.

Observations on the Ecology of Colorado Squawfish in the Yampa River, Colorado, 1982. Tech. Rep. 83-7.

Hydraulic and Sediment Transport Investigation, Yampa River, Dinosaur National Monument. Tech. Rep. 83-8.

Measurement of Bend Flow Hydraulics on the Fall River at Low State. Tech. Rep. 83-9P.

Development of a Water Quality Monitoring Program for the Big Thicket National Preserve, Texas. Tech. Rep. 84-Bith-1.

Bedload Transport and Hydraulic Geometry Relations for Fall River, Rocky Mountain National Park, Colorado, June-August 1983. Tech. Rep. 84-Romo-1.

Long-term Research into the Effects of Acidic Deposition in Rocky Mountain National Park: Summary Report 1980-1984 (available in January 1985). Tech. Rep. 84-Romo-2.

Portable Kits for Water Chemistry Reconnaissance in the Field. Tech. Rep. 84-2.

Specific Conductance and pH Measurements in Surface Waters: An Introduction for Park Natural Resource Specialists. Tech. Rep. 84-3.

A Resource Manager's Guide to Water Quality Criteria (available in December 1984). Tech. Rep. 84-4.

Requests for reports should be sent to Chief, Water Resources Branch, National Park Service, 301 S. Howes, Fort Collins, Colo. 80521.

National Capital Region

Jim Patterson, NPS regional agronomist for NCR, presented two lectures at the invitation of the American Society of Landscape Architects at the Society's national meeting in Phoenix in November. His subjects were urban soils and site conditions.

Systemwide Surveys Take Measure of Interpretive Programs

By Richard L. Cunningham

From December 1982 through January 1983, a survey of how natural resource management, cultural resource management, and visitor safety were being interpreted to park visitors was conducted throughout the National Park System.

The three surveys were intended to depict how park interpretation was being used to address specific resource management and visitor safety concerns. Publication of the survey results would provide a means for sharing this information to parks with similar concerns.

Two simple survey forms were developed; one for natural or cultural resource management and one for visitor safety.

The Regional Chief of Interpretation, Western Region, was responsible for conducting the survey, analyzing the survey returns and developing a final publication for servicewide distribution. The final publication, "Interpretation of Natural Resources Management, Cultural Resources Management, and Visitor Safety in the National Park System" was published by the Branch of Interpretation, Washington Office. This publication includes data on natural resource management and visitor safety; the cultural resource management survey will be published at a later date.

A total of 1,400 survey forms for all three subject matter surveys were received from 221 National Park areas. Survey forms returned included: Natural Resources Management – 590; Cultural Resources Management – 332; and Visitor Safety – 478.

The 590 Natural Resources Management survey forms were submitted from 145 different National Park Service areas. These survey forms were divided into 18 topics based upon related types of responses. The topics are General and Miscellaneous; NPS Policies, Ecosystems Management; Backcountry Management/Minimum Impacts; Fire Management; Erosion/Off-Trail Use; Impacts on Sand Dunes; Cave Management; Exotic Animals; Exotic Plants; Bear Management; Wildlife Management; Feeding Wildlife; Collecting Plants/Picking Wildflowers; Collecting Animals/Poaching; Collecting Fossils, Rocks, Petrified Wood; Littering; Vandalism.

Death Valley developed an excellent four-method approach for communicating its burro management program: an evening slide program, an on-site guided walk to an area of heavy burro impact, a series of public discussions with the Superintendent, and throughout, an opportunity for the public to sign-up to receive management plan summaries. Hawaii Volcanoes developed a special exhibit on feral pigs. Everglades and Coulee Dam developed interpreter role-playing programs on exotic plant control.

Twenty-six parks returned 49 survey forms on fire management interpretive activities. Yosemite uses "fire roving" interpreters at sites of management fires. Big Thicket features half-day guide walks that demonstrate prescribed burning techniques. Olympic has developed a professionally produced slide/sound program for local off-site educational use. Grand Canyon has several articles in its park "newspaper" on fire management. Interpretive activities on air quality have been given at Capulin Mountain, Grand Canyon, and Chiricahua. Redwood offers a conducted trip to understand the watershed rehabilitation project.

One of the most innovative programs was at Everglades featuring "Developer Dan", a role-playing interpreter who wants to buy the land and develop it. Some wildlife management programs included Cape Cod's conducted hikes to observe tern colonies; banding Cave Swallows at Carlsbad Caverns; a mail-away slide program on Bald Eagles at Glacier; on-site guided walk at Padre Island when the endangered Ridley Turtles are released; and several parks with live snake demonstrations.

Of the 590 Natural Resources Management survey forms submitted, 400 were selected as best representative of a wide range of interpretive methods. Each park in the system has received a copy of the summary publication. Each regional office has received two sets of the actual survey forms and has the responsibility of distributing the forms to the parks upon their request.

Further information can be provided by the Regional Chief of Interpretation, Western Region (415) 556-3184.

Cunningham is Chief of Interpretation for the NPS Western Region.

information crossfile

"Interpretation: To What End?" by Bob Peart, manager of Informal Learning Environments Consulting Services in Victoria, B.C., appears in the Fall issue of the *NPS Ranger Newsletter*, reprinted there by Editor Bill Halainen with permission from *The Interpreter*, the Western Interpreters Association Journal for Environmental Communicators.

The article is based on a 1978 paper by J. P. Foley and J. A. Keith, and considers interpretation as a fourfold program: (1) as a tool for attitude change, (2) as a management tool, (3) as an educational tool, and (4) as a recreational/inspirational experience. The recreational/inspirational experience "should be dominant," according to the authors.

"The other three categories," they write, "for reasons of less direct advantage to the public, questionable messages considering our audience, lack of presence of the object being interpreted, secondary level rather than primary goal development, and lack of application for the total profession were deemed less suitable as the philosophical foundation upon which to base programs."

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Development of a policy to control acid rain is lagging behind the pace of research, according to an article by Ivars Peterson in the July 28, 1984 issue of *Science News* entitled "Acid Rain's Political Web."

"Delaying action will allow emissions to remain high for a decade longer with the risk of further ecological damage," the article states, but "acting now involves the risk that the control program would be less cost effective or efficient than one designed later."

The report sums up the "contradictory or ambiguous" information about acid rain's effects on agricultural crops and human health, the growing evidence of acid rain damage to lakes and streams and possibly to forests, and the fear of a deepening of regional divisions while the issue of "who pays?" remains unresolved.

"At the moment," Peterson concludes, "a legislative solution seems far away. Meanwhile the research continues, and the rain falls."

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"How Many is Too Many?" is the title of a 103-slide, 19-minute slide/tape program introducing the concept of carrying capacity as it applies to recreation management and describing a conceptual model for determining recreational use limits. Studies from a variety of outdoor recreation settings were used to develop the model, which is illustrated with a case example.

The program was put together by Assoc. Prof. Bo Shelby of Oregon State University's Resource Recreation Department, and Stacy Mellem, OSU Forestry Media Center specialist. The program is available for rent ($18) and purchase ($105), from the Forestry Media Center, College of Forestry, OSU, Corvallis, OR 97331-5704. The program is intended for resource managers and students interested in issues of crowding and overuse.

Dear Readers: Information Crossfile is a two-way proposition. We hope you're picking up tidbits of information you might otherwise have missed, but we'd like also to hear from you when you read something informative that you feel should be shared. Instead of just mentioning it to a colleague, send it to *Park Science* and share it with a whole *lot* of colleagues.

We're particularly interested in things that present the objective elements of research and management situations . . . articles that handle crucial matters with the least possible emotion and bias . . . maximum enlightenment, minimum heat! Send in your selections and we'll print them with thanks to you for the assist.

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"Tourism and the Environment: A Review of the Literature and Issues" by D. Reber Dunkel, is featured in the Spring 1984 issue of *Environmental Sociology*, Newsletter of the American Sociological Association's section on environmental sociology. The review provides a cross-section of works that address several key dimensions of tourism and the environment – a relationship that the author describes as ambiguous.

Sections include examinations within an overall theoretical framework, of the whole idea of tourism as a social practice that appropriates nature, (this under the heading of "theoretical concepts and national park polemics), social impacts, environmental threats to and from tourism, and policy and planning. Growing concern over the natural resource limitations to tourism has led, according to Dunkel, to consideration by *The Annals of Tourism Research* for a special issue on Tourism and the Biophysical Environment. Guest editor is Dr. Bryan Farrell, Board of Environmental Studies, Pacific Research Unit, University of California, Santa Cruz, CA 95064. (408/429-2195).

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From *Science* (Vol. 226, p. 150) comes word of a major private effort to collect and preserve the more than 3000 endangered varieties of plants in the United States. Developed by scientists from 14 leading U.S. botanical gardens and arboretums, the program calls for establishment of a national Center for Plant Conservation . . . to be divided into regional centers where climate and scientific expertise will be most closely suited to particular plant varieties. Headquarters for this proposed consortium of botanical gardens will be at Harvard University's Arnold Arboretum.

Frances Thibodeau, acting scientific director of the Arnold Arboretum, sets at 10 to 15 percent the wild species in this country that are either seriously endangered or threatened. "By growing them in botanical gardens," the *Science* article states, "researchers will be able to study their growth and ecological requirements . . . (and look for) sources of unrecognized medicinals or other potentially useful chemicals."

***

"The Proper Display of Data" by Gina Kolata in the Oct. 12, 1984 issue of *Science* discusses means of improving graphs as an aid to presentation of scientific information. The author cites the work of AT&T Bell Lab scientists, who sifted through the journals and found not only a great lack of imagination in the use of available new graphing techniques, but a 30 percent occurrence of at least one error in the graphs. Readers surveyed were found to have difficulty in judging graph slopes or vertical distances between curves. Investigators also questioned the convention of putting one standard error bar on graphs as "a knee-jerk reaction" to the numerical convention for describing sample-to-sample variations – suggesting that graphs should be drawn to show confidence intervals rather than standard errors.

Overall, the message is that scientists could improve their graphical analysis presentation of data by learning some of the new methods of displaying data – methods recently invented by statisticians.

***

"The Social Impacts of Energy Development on National Parks" is the title of a 90-page Report done by the Cooperative Park Studies Unit at the University of Denver for the WASO Division of Special Science projects, NPS. The history of energy development in the American West can be described as the cyclical recurrence of boom and bust, the fluctuations of which will continue in the aftermath of changes in supply and demand of energy resources. The Report should be of value to all who are entrusted with enhancing our parks for public use and protecting their valuable resources, according to Al Greene, Chief, Special Science Projects Division. The Report is available from the Division, Washington, D.C. 20240.

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From Seattle, Jim Larson sends in news of two disease resistant elms. The Morton Arboretum in Lisle, Ill., under George Ware's direction, has been working with crosses of Asian elms and has come up with a disease resistant Japanese-Wilson elm hybrid. Cuttings are being made available to nurseries for commercial propagation.

The Elm Research Institute in Harrisville, NH 03450, offers a strain of the American elm developed at the University of Wisconsin and named the American Liberty elm. The Institute has several give-away programs, as well as some available at minimal prices.

***

From R. Gerald Wright at the NPS/CPSU in Moscow, Idaho, comes the following summary of an article by Stuart H. Hurlbert in *Ecological Monographs*, 54:187-211 (1984), entitled "Pseudoreplication and the Design of Ecological Field Experiments."

"This recently published paper should be required reading for all researchers. It deals with the importance of the proper design of field experiments. The author defines pseudoreplication as the use of inferential statistics to test for treatment effects using data from experiments where either treatments were not replicated or the replicates were not statistically independent. In such cases, the statistical tests are inappropriate. In an extensive survey of the ecological literature, the author found that 42 percent of recent statistically analyzed field experiments suffered from this problem.

"The article discusses case examples of several experimental situations in which this can happen. It also attempts to establish some common terminology and clear up some of the semantic confusion that abounds in literature on experimental design.

"It also raises several important philosophical points. It recognizes that it is often impossible to replicate large field experiments such as those that typically take place in parks. It points out that the problem is not necessarily with the design, but rather with the fact that when tentative conclusions are derived from such unreplicated treatments, they are given the unmerited veneer of rigor by the erroneous application of inferential statistics."

Observations from Outside

By Jerry F. Franklin
Chief Plant Ecologist, USDA Forest Service
Corvallis, Oregon

(Based upon opening remarks made at the Second Biennial Conference of Research in California's National Parks, University of California, Davis, California, Sept. 5-7, 1984.)

As I look back over 15 years of association with National Park Service research I am astonished with the progress in NPS science programs. There are many indicators of the thriving state of NPS science. Quantity and quality of scientific staff are up. NPS scientists are participating in scientific meetings in greater numbers and publishing in refereed outlets. This participation and the better training is reflected in higher overall credibility for NPS science and staff among peers and lay public.

The quantity of science being conducted has increased and there are now Parks and research groups approaching critical scientific masses. Efforts at Sequoia-Kings Canyon, Channel Islands, and Redwoods in California reflect these concentrations as does earlier establishment of the center at Everglades.

The nature of NPS science is changing with greater attention to larger issues and to interdisciplinary approaches. Interactions with managers are typically good, despite occasional differences over priorities.

Many NPS scientists may be too close to appreciate the progress. NPS science has become an element to be reckoned with in the field of ecology, however, and I am telling scientific and managerial scientists so whenever I have an opportunity.

Yet, there are some aspects of NPS science that need to be strongly encouraged.

Relativities and Probabilities. There is increased attention to relativities in ecological science as opposed to absolutes. The null hypothesis approach to ecology has contributed to our progress but, unfortunately, it also has encouraged scientists to think in terms of either/or situations. Is the assertion that, "competition is the process responsible for the structuring of communities" true or false? The answer is YES as it is for so many biological phenomena.

Many processes or structures are proving to be operative in ecosystems. It is their relative importance or even occurence that varies drastically from ecosystem to ecosystem. This may seem very logical but you might not get that impression from the ecological literature where reputations are made defending the universality of a particular concept.

The increased appreciation of variation across ecosystems should result in more research comparing ecosystems in time and space. It should also result in greater consideration of stochastic elements, a recognition of probabilities, as when considering disturbances, such as fire, or regeneration behavior of two plant species. All of this effort would be directed to prediction of ecological responses.

Appreciation of Natural History. There is a resurgence of appreciation of the need for knowledge of the natural history of the ecosystems and organisms with which we are working. I have often been dismayed at the low esteem with which some scientific leaders have held such research; yet it has always seemed to me to be the essential core of any ecological research program. Some scientists have suggested that we avoid the need for such research through reliance on theory. Yet, the general models of the theorists provide us with little ability to predict ecological outcomes. As one noted ecological theorist commented several years ago, he relied on his knowledge of the natural history of involved organisms or ecosystems and not classroom theory whenever confronted with a real-world ecological problem.

Of course, ecological theory can contribute to our concerns in applied ecology; it is a broad and varied field. The general constructs of theorists can stimulate us (e.g., the successional strategems of Eugene Odum) and there are ecological problems to which existing theory has application, such as in disease epidemiology or population biology.

Generally, however, we are going to have to know at least the general features of our ecosystems and constituent organisms. And we are going to have to construct models that use this information to provide probabilistic predictions. Fortunately, we see models emerging that do incorporate these features, such as the forest successional models JABOWA and FORET.

It is important that we recognize that technology cannot be substituted for an investment of time and dollars to obtain accurate and comprehensive natural historical knowledge. Sophisticated technology, whether computers, remote sensing or in some other form, can facilitate such work and we should use it to the fullest. But ecological diversity demands a thorough knowledge of individual park ecosystems and organisms for effective management, i.e., management which achieves its conservation objectives.

Holistic Viewpoints. Holistic viewpoints are increasingly emphasized in ecological research. This reflects increased appreciation that you cannot understand or manage species, processes or structures in isolation; the need is for understanding the relationships among the parts of a whole ecosystem. It also reflects the fact that the most interesting ecological questions (in my opinion) and the most relevant ecological questions (to society or park managers) involve whole ecosystems. We see this again and again, e.g., with regard to impacts of atmospheric pollutants, re-creation of an old-growth forest condition, or explanations of declines in a caribou herd.

The holistic perspective encourages collaborations between disciplines and between institutions. The breadth of knowledge required exceeds that of any single discipline let alone individual. Similarly, the breadth and depth of resources required often exceed the ability of a single institution or agency.

Long-term viewpoints are being encouraged after being in bad odor for many years. The National Science Foundation, reflecting a consensus in the ecological community, has recognized the need for long-term data sets and experiments and is providing approximately four million dollars a year to support it. Long-term studies are simply the only way in which many important questions in basic and applied science are going to be definitely resolved. Long-term data bases are necessary to identify trends, measure rates of long-term processes, provide baselines, develop an appreciation of and information on episodic phenomena, and provide the raw meat for formulating and testing hypotheses.

Unfortunately, the reward system for scientists has worked against a long-term orientation.

Implications for National Park Service Research

What do these trends have to do with future National Park Service research and, more broadly, future research in National Parks? Quite a bit.

We must begin by recognizing at the outset that the parks are unique as scientific properties. They are society's best baseline areas. They are the best examples of the structures, organisms, and processes found in natural ecosystems. To fulfill their potential function as baseline areas and to provide information necessary to manage these properties, NPS science is going to have to work harder and NPS scientists are going to have to accept some special responsibilities.

There needs to be a greater emphasis on long-term research. This may take many forms – establishment of permanent plots, observation of ecological processes-organisms-structures over long time periods, establishment of exclosures and (yes!) of manipulative experiments. Past mistakes need to be avoided. Exclosures are a good example of an invaluable approach to some long-term studies but they have developed a bad name, largely because of inadequate documentation and pretreatment measurement. The new generation of long-term projects needs to have well-defined objectives, thorough documentation of procedures, adequate field marking, careful data archiving, and continuity in maintenance. NPS needs to develop an institutional committment to such long-term efforts and an institutional memory to insure that such projects are not lost with loss of individual scientists or managers.

NPS science needs to identify the essential long-term programs and find the resources to carry them out. Persuade management; bootleg when you have to. This is your responsibility to the parks, and to the future generations of resource managers and scientists. Given the transient validity of much of the information we generate (ecological science is a science of successive approximations, not truths), the legacy in long-term installations and data may be your more permanent legacy.

There are NPS programs that provide excellent models. The acid rain baseline projects, for example, are one good start. Here is a program that is being used to serve both immediate and long-term objectives. Each of these projects is becoming the core of a major NPS long-term ecological research program. They are projects to which many other studies can be added in future years. A superior example of long-term monitoring is provided by the marine monitoring program being established at Channel Islands. It is biologically and statistically sound, well documented, and adequately marked in the field. I will guarantee that some very exciting science is going to come from that effort, in addition to the baseline data needed by management.

There needs to be greater emphasis on whole ecosystems. NPS scientific programs tend to focus on current problems, symptoms rather than causes, heroic species, conspicuous phenomena, and political concerns. These tendencies are always going to be present and for good reasons. The emphasis on research contracting and on yearly decisions for funding also tends to result in fragmented looks at ecosystems. It is important that NPS science and management staff collaborate in developing programs which provide a more comprehensive perspective.

NPS scientists have a special responsibility to take a holistic view of the ecosystems with which they are dealing. You need to provide leadership in planning and conducting interdisciplinary and interinstitutional collaborations. Such efforts are essential to resolution of so many critical resource issues and to documentation of baseline conditions. A part of this job is the responsibility for integrating the information that is developed for these ecosystems, all of the many bits and pieces. If *you* do not do the job of synthesis, who will?

NPS scientists need to become the recognized experts in their ecosystems. You need to be the leaders in conceptualizing and carrying out the projects. You need to be the authors of the definitve monographs.

Ungulates, Highways and National Parks Or 'The Mountain Goats of U.S. 2'

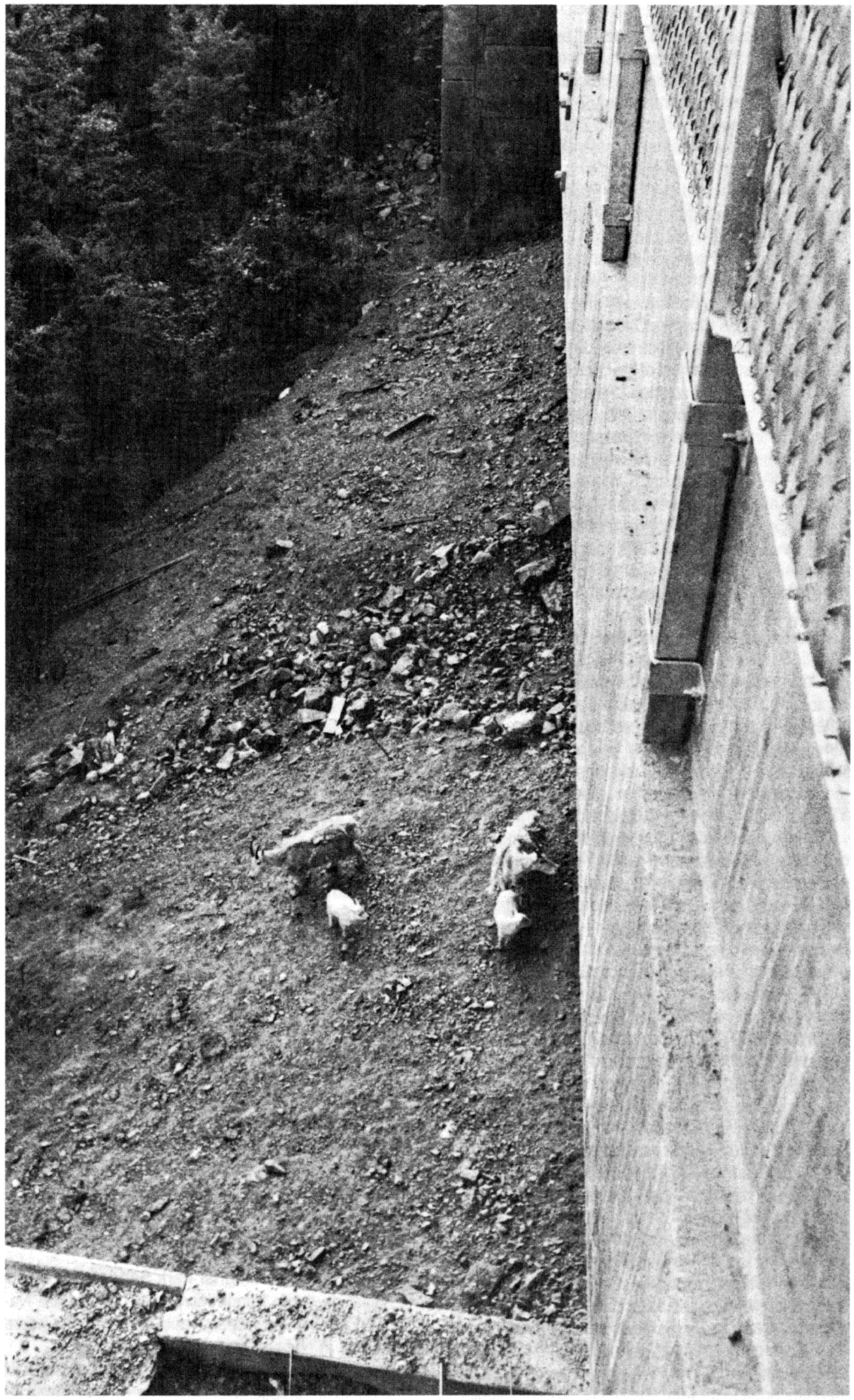
By Francis J. Singer, Cathy Pedevillano, and R. Gerald Wright

A problem common to all National Parks is to provide for visitor access yet protect natural resources from undue human disturbance. Wildlife in parks is particularly vulnerable to disturbance and mortality along park roads that traverse winter range or wildlife concentrations areas. This is especially true when roads carry through-traffic at high speeds. This paper presents some of the results of studies dealing with the reconstruction of U.S. Highway 2 in Glacier NP past a mineral lick extensively utilized by mountain goats. The findings of other published studies and the highway-ungulate observations of the senior author in the Rocky Mountain National Parks of western Canada (Banff, Jasper, Yoho, Glacier, Kootenay), also are discussed.

U.S. Highway 2 traverses the extreme southern tip of Glacier NP for a distance of 4.5 miles. There it bisects a movement corridor used by mountain goats seasonally travelling to and from a mineral lick located on the banks of the Middle Fork of the Flathead River. U.S. 2 is the only northern highway across the Continental Divide in Montana and it carries heavy truck traffic. Highway reconstruction in 1966 excluded the Glacier NP section, leaving the road there sinuous and narrow. This section of road was more difficult to negotiate and to keep clear of snow and ice than adjacent sections, and had a higher accident rate.

Visitors stopped along the roadway to view goats on the lick and probably had done so ever since the highway was constructed. In 1975 it was estimated that 64,000 people visited the goat viewing area and about ⅔ probably saw goats. The area ranked as the second highest visitor use area in Glacier and affords the most significant mountain goat viewing area in North America. Studies of the road environment and the mountain goats in this area began in 1975. Although the very low average vehicle speeds (25-28 mph) past the lick area enabled drivers to stop for goats, still 13 near hits were observed, indicating the high potential for goat mortality if highway speeds were increased. The construction plan called for a design speed of 45 mph or greater, and therefore crossing facilities for mountain goats were considered manditory. Constructing a highway bridge that allowed mountain goats to pass beneath seemed the best solution.

Many ungulates, e.g. mule deer, elk, white-tailed deer and caribou, will use underpasses, although pronghorn antelope will not. A goat overpass over the highway was rejected due to numerous safety hazards associated with such a structure on Trans-Canada 1 in Glacier NP, British Columbia. The hazards included shading of the pavement, black ice, and goat mortalities at the entrances. During highway reconstruction, a specially designed goat underpass was built and a second bridge over a canyon was altered to accommodate goat passages. The construction also included restrictive fencing upslope and a sheer wall downslope to eliminate goat access to the highway and cause them to use both underpasses. NPS management objectives and the high visitor use dictated that people be allowed access to view goats even though they tended to disturb the crossing goats, and their slow driving (or stopping) on the highway posed a conflict with faster through



Mountain goats *are shown here using one of two highway underpass structures, Goat Bridge and Snowslide Bridge. The bridges afford goat movement downhill to the Walton Goat Lick in Glacier NP and uphill away from the lick. Cyclone fencing and retaining walls prohibit goat crossings of U.S. Highway 2 except under the bridges or around the ends of the structures.*

traffic. To alleviate these problems, a new viewing site was constructed, away from the underpasses, consisting of a parking area with safe entry to and exit from the highway and a foot trail leading to an overlook viewing the lick.

Visitor use of this new goat viewing area was monitored in 1983 and 1984 after all construction was completed. Approximately 34 percent of all vehicles travelling Highway 2 pulled off into the parking area from May to September of both seasons. Visitors using this area numbered 73,660 in 1983, and 83,860 in 1984. About 63 percent of all visitors who used the parking area took the trail to the overlook to view goats. Visitors remaining in these designated areas did not disturb mountain goats utilizing the underpasses or mineral lick. Although use of this goat-viewing area was considerable, the problem of visitors and vehicles stopping on the highway during goat crossing remained, although at lower levels than before reconstruction. Eliminating highway shoulders near the bridges and temporary barricades and signs may alleviate this problem.

Reactions of the goats to the construction activities and artificial barriers were monitored during 1980 and 1981. During construction, goats initially hesitated in front of, butted, or attempted to crawl under temporary fences placed across their trails. However, goats eventually drifted with the fences, and within weeks, the rate of hesitations and physicial contact became negligible. No physical injuries to goats occurred during construction, although eight groups inadvertently entered gaps in temporary fencing and were trapped for periods up to six hours; one of these groups eventually jumped off of the eight foot high wall. During the construction period mountain goats seemed undisturbed while at the lick. In comparison to the pre-construction data from 1975, the number of hesitations, runbacks and altered routes per crossing attempt declined by about one-half. Instead of ceasing to visit the lick by early August, a few goats in 1980 extended their visits to the lick throughout the fall and winter.

This increase in crossing frequency and success may have been due to the fact that goats always were allowed open access across the road during construction. Blasting was restricted to 0800-1200 hr. when few goats crossed the road; construction activity was not conducted in the main crossing area during key times (0600-0730 hr., 1800-2200 hr.; and between Aug. 15 and Oct. 1), traffic was stopped for crossing goats, and few visitors exited their vehicles. This reduction in vehicle speeds and in interference by visitors was more significant to crossing goats than the additional drillings, blasting, bulldozers and other operating equipment and construction workers.

Immediately following construction, mountain goats readily accepted the two new underpasses built for them. A total of 99.4 percent of observed goats used the underpasses; highway crossing success increased by 16 percent; the number of hesitations and runbacks per crossing attempt further declined; the incidence of erect tails, which indicate fear, declined in crossing goats, and the number of lick visits per goat per year doubled after completion of the underpass. The extension of lick visits into winter and doubling of lick visits per goat per year was interpreted as a return to more natural conditions following the underpass construction.

By 1983 and 1984, the mountain goats were well habituated to the crossing structures and 100 percent of all observed goats used the underpasses to cross the highway. Loud vehicles passing by and people stopped on the bridge presented the greatest disturbance to crossing goats, and would sometimes result in hesitations, runbacks, delayed crossings, and erect tails. These reactions occurred less frequently after the underpass construction than before. Goats seemed to prefer using the highway bridge underpass which afforded greater visibility, but would sometimes switch to using the goat bridge when confronted with high levels of vehicles and visitors. During undisturbed crossings, mountain goats would often dustbathe, bed or lick eroded road salts underneath the bridges. Lick visits continued to extend into winter as several goats began using the lick in April of 1983 and February of 1984.

The guidelines for ungulate crossing facilities used in this study were based upon other work with mule deer, elk and caribou. They include: (a) where average highway speeds exceed 35 mph, crossing structures are often justified for safety reasons, (b) underpasses or other crossing structures should not be confining (24 feet × 24 feet for mule deer, 12-24 feet × 24 feet plus for goats), (c) the visual window presented by an underpass should be as large as possible, (d) crossing structure should be placed on a natural movement route, (e) fencing should parallel rather than bisect movement routes and should be totally restrictive, (f) park visitors should be restricted from the crossing structures to the maximum extent possible, (g) cover or shielding near the entrance to the underpass or other crossing structure will increase its acceptance by ungulates.

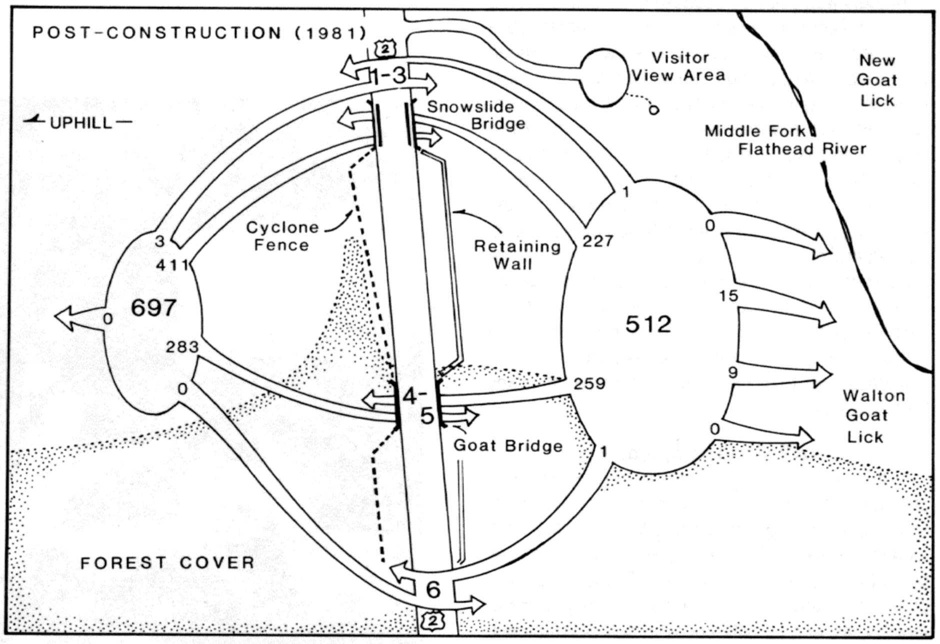
Acceptance of the Glacier highway underpasses by mountain goats is among the highest known for any free-ranging ungulate herd. In the first year of use, 99.4 percent of all goats used the underpasses with only 550 feet of lead-in fencing. Only 61% of a mule deer herd used a more confining underpass with two miles of fencing on I-70 near Vail, Colo., and 15 miles of lead-in fencing were required on I-80 in Wyoming to force mule deer to use the crossing structures.

We attribute the high acceptance of the underpasses on U.S. 2 to strict adherence to the above guidelines and to the step-wise progressive construction of the facilities. The high number of lick visits per year for each goat also provided them the opportunity to encounter the facilities repeatedly and to adapt to them. Protection of goats from hunting and harassment also contributed to goat adaptation.

The need for ungulate highway crossing facilities in national parks is evident from the above examples. These should be seriously considered whenever large numbers of visitors and vehicles travel through ungulate concentration areas to insure the safety of both humans and wildlife.

Singer is a Research Wildlife Biologist with the NPS Alaska Region in Anchorage; Pedevillano is with the University of Idaho Dept. of Wildlife Resources; Wright is an Ecologist with the NPS/CPSU at the University of Idaho, Moscow, 83843.

Off-highway mountain goat viewing *area affords visitors in Glacier NP the opportunity to see the goats without running the risks entailed in trying to observe from the highway.*



Two goat bridges under U.S. Highway 2 *and a new, off-highway visitor viewing area deal with the problems and opportunities presented by mountain goats and an established salt lick in Glacier National Park.*

Integrated Watershed Research Undertaken at Sequoia National Park

By David J. Parsons and David M. Graber

By David J. Parsons and David M. Graber

Park managers and scientists both are fond of bemoaning the lack of funds for baseline studies of the natural resources of our national parks. Yet when the development of a resource inventory or long-term monitoring program is priced against the more critical protection of a sensitive species or the resolution of a visitor/resource conflict in a priority-setting meeting, baseline data-gathering invariably loses out. Ironically, this ensures the continual generation of new crises – problems that develop unnoticed until they are obvious . . . and severe. There are few examples of the resource data bases necessary to adequately monitor the health of sensitive ecosystems in our national parks.

Acid Precipitation as a Catalyst

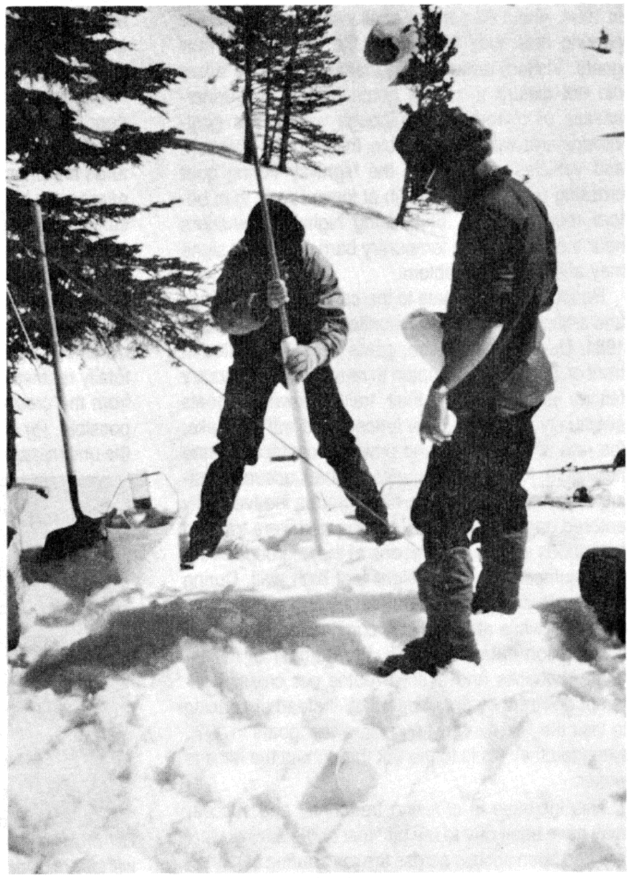
In Sequoia and Kings Canyon NPs we recognized some years ago our need for a modern, comprehensive, integrated resource data base including all major park ecosystems. Through normal budget processes it never was possible to obtain the necessary funds. In 1982 the Park was invited to become one of three NPS areas to embark on a long-term monitoring project as part of the National Acid Precipitation Assessment Program (NAPAP). Funding is provided by the NPS Acid Precipitation Program, a part of the Division of Air and Water Quality, under Ray Herrmann's direction in Fort Collins. The three National Parks (Sequoia, Isle Royale and Rocky Mountain – Olympic has since been included) were directed to develop coordinated programs to measure atmospheric inputs and to determine – and then monitor – ecosystem parameters potentially sensitive to acid precipitation.

Sequoia was selected because of its location in the southern Sierra Nevada where poorly buffered granitic bedrock and low alkalinity lakes are challenged by significant air pollution, making it one of the most sensitive areas in the country to acid precipitation. The Park staff saw this as an opportunity to obtain much of the baseline data that had proved elusive for so long. In order to evaluate impacts from acid precipitation, it is necessary first to measure many of the same ecosystems parameters affected by visitor use, park operations, and a variety of threats to entire ecosystems: air pollution, exotic biota, island/boundary effects, wildfire suppression. Here was an opportunity to contribute directly to a major national research priority while simultaneously obtaining the data necessary to monitor the long term health of key Park ecosystems.

An Ecosystem Approach

In the early planning stages we decided that one of Sequoia's particular contributions to such a study is its elevation gradient, ranging from less than 400 meters at Park headquarters to more than 4,400 meters, at the top of Mount Whitney. The strong atmospheric inversion layer that develops during summer months, as well as differences in soil development, climatic regime, and vegetation suggest that major differences in susceptibility to anthropogenic pollu-

Synergy at work: *Winter snow sampling (upper photo) and filtering of water samples for chemical analysis are part of the cooperative venture at Sequoia National Park, providing five years' support for high priority research in such areas as snow hydrology and chemistry, aquatic biology, soil processes, and tree ring and plant productivity studies – all contracted to university scientists working in the park.*



tants may exist at different elevations. We established three primary study sites (table 1) consisting of headwater drainage basins for which aspects of hydrological and chemical budgets as well as key ecosystem processes can be measured. In many ways we modeled our program after the highly successful long-term ecosystem study at Hubbard Brook, NH. It was apparent from the beginning that to execute our extensive plans it would be necessary to attract cooperative funds and extramural participation. While the modest NPS/NAPAP funds available for the project would support monitoring of input chemistry and a smattering of ecosystem measurements, they were inadequate to implement one integrated watershed study, let alone three.

As the scope of the study (and of the entire NPS program) was refined, priorities sorted themselves out. We assigned top priority to measurement of the quantity and chemistry of rain and snow entering the basins, and of streamflow leaving them. Although, we suspected – and still do – that dry deposition could be the most significant mode for pollutants entering our relatively arid mountain range, there are no generally accepted methods to measure such inputs. We have decided that measurements of dry deposition must await new technology and the formulation of EPA protocols. Other high priority studies included the chemical characterization and mapping of soils and the establishment of permanent vegetation plots to monitor plant species composition and demography.

As word spread about our program we discovered that others were interested in related or complementary studies and in many cases were looking for a place in California to carry out such work. Some of these scientists or agencies were specifically interested in acid precipitation and its effects, others in oxidant air pollutant impacts, and still others in particular structural or process elements of natural ecosystems. But all were attracted to the undisturbed aspect of park ecosystems, the cooperative integrated nature of the project, and the Parks' moral and logistical support for the endeavor.

Within the two years since the acid precipitation study first began, Sequoia NP has become a center for long term ecological research. Several federal agencies, the State of California, university scientists, and private industry have thus far participated in what has become a truly cooperative effort. While each party has its own specific interests, all have a common commitment to an ecosystem-level scientific program that will help make our world a better understood and safer place for future genertions.

Cooperation

Cooperating investigators and funding sources as of fall 1984 are listed in Table 2. The U.S. Geological Survey has designated Emerald Lake a "calibrated watershed," one of a half dozen or so scattered across the country. The Survey has constructed a gauging station at the lake outlet, and performed chemical analyses of lake water using extremely sensitive detection limits, as its contribution towards building a water and ion budget for the watershed. The Survey also provided valuable information on the geology and geomorphology of the Emerald Lake and Log Meadow areas as an extension of a survey of groundwater hydrology carried out for the Denver Service Center.

National Park Service acid precipitation funds have been used to establish and survey the three primary study sites, including the selection of long-term vegetation monitoring plots. Inputs of rain and snow (both quantity and chemistry) as well as outputs through stream discharge and basic meteorological parameters also have been measured as part of a system of "core requirements" to be carried out at each participating park. NPS funds also have been used for research contracts at each participating park. At Sequoia, NPS funds have supported mapping soils in the drainage that includes all 3 study sites and for preliminary studies of soil chemistry, aquatic chemistry and biology, and effects of drought stress on plant phenology and water relations. Beyond its immediate utility, we believe that such information can serve to attract support and expertise for further investigations.

Interest of State university scientists in the developing study has been notable. The soils work has been supported partially by University of California Hatch Act funding obtained by the principial investigators. Dr. Jerry Franklin of the U.S. Forest Service in Corvallis, Ore., provided an early stimulus to data collection as well as instruction in handling cooperative ecosystem studies. Dr. Franklin combined NPS Interdisciplinary Science Team funds with Forest Service support to bring upwards of 50 scientists, technicians and students, primarily from Oregon State University, to take a "pulse" (short-term, intensive measurement) of the mixed conifer ecosystem at Log Meadow. This proved a stimulating experience and helped convince us that our program could be successful.

Less than a year into the program, NASA-Ames Research Center contacted us to learn if we would be interested in providing Sequoia as a field site for portions of NASA's new Global Biology program. NASA is testing remote sensing techiques to predict vegetative cover, litter fall and eventually nitrous oxide emissions from the soil as part of a broad effort to quantify cycling of key elements. While NASA has no particular interest in acid precipitation it is interested in finding a study site in the Sierra where basic ecosystem data is available. NASA-Ames is now directly supporting major studies of forest biomass/productivity and soil nitrogen flux in Sequoia. These are identified needs in the Park's research plan that had not yet been filled. Moreover, NASA has provided satellite and high-altitude aircraft imagery of the study sites, and invaluable technical advice on remote sensing, computing and development of a geographic information system.

More recent, but also most significant, has been the involvement of the State of California's Air Resources Board (CARB) in funding acid precipitation research; their entry promises to make the Sequoia program a fully functional ecosystem study. Following 1982 legislation calling for a five year multi-million dollar research thrust on acid precipitation, and after eager solicitation on our part, CARB selected Emerald Lake for the focus of its integrated watershed study.

Significant in its site choice was the work already accomplished, and the benefits of synergy. This cooperative venture provides five years' support for high priority research in such areas as snow hydrology and chemistry, aquatic biology, soil processes, and tree ring and plant productivity studies. These

TABLE 1. Primary study sites for long-term ecosystem study in Sequoia National Park.

Watershed	Type	Elevation	Area	Geology	Vegetation
Elk Creek	Intermittent stream	750 m	5 ha	Granitic	Chaparral
Log Meadow	Perennial stream	2,070 m	39 ha	Granitic	Sequoia mixed-conifer forest
Emerald Lake	Lake/stream	2,800 m	122 ha	Granitic	Subalpine

TABLE 2. Participants in acid precipitation studies, Sequoia National Park

Sponsor	Principal Investigator	Study	Site*
1. NPS	D. Parsons, D. Graber, T. Stohlgren, NPS	Project Coordination, meteorology, precipitation and stream chemistry, long term vegetation dynamics	1, 2, 3
2. NPS/CARB	J. Melack, S. Cooper, R. Holmes, UCSB	Aquatic biology and lake chemistry	1, 2
3. NPS/CARB/NASA	P. Rundel, W. Westman, UCLA; T. St. John, Colo. St.; S. Running, U. Montana	Vegetation and mycorrhizae studies	1, 2, 3
4. NPS/UC	G. Huntington, M. Akeson, UCD	Soils mapping	1, 2, 3
5. NPS/UC	R. Burau, L. Whittig, UCD	Soil chemistry	1, 2, 3
6. CARB	J. Dozier, J. Melack UCSB	Snow hydrology and chemistry	1
7. CARB	S. Nodvin, L. Lund, UCR	Soil processes	1
8. CARB	J. Harte, R. Amundson, UCB	Lake sediment buffering	1
9. NPS	P. Miller, USFS	Ozone effects	2
10. NPS	C. Wetmore, U. Minn.	Lichen survey	2,3
11. NPS	J. Moore, T. Sisson, C. Wahrahaftig, USGS	Geology	1, 2
12. USGS	V. Kennedy, R. Schroeder, T. Hunter, USGS	Stream chemistry and hydrology	1
13. MAB/USFS	P. Miller, USFS, and L. Lund, UCR	Dry deposition	3
14 CARB	T. Nash, Ariz. St. U.	Tree ring chronology	1
15. EPRI	R. Newton, Smith College and R. April, Colgate U.	Surficial geology and mineralogy	1
16. SCE	G. Bradford, UCR	Lake chemistry	1
17. NASA	P. Matson, NASA-Ames	N mineralization and canopy nutrients	2,3
18. NASA	L. Band, Hunter College	Digital terrain	1,2

*1 – Subalpine (Emerald Lake); 2 – Mixed conifer forest (Log Meadow); 3 – Chaparral (Elk Creek)

Park Science Reader Survey

Within the next few weeks, a readership survey will be conducted in order to help the editorial board and the editor of *Park Science* get a "feel" for what you like and what you miss finding in *Park Science.*

Scientifically prepared, easy-to-answer, vital-to-us questionnaires will be mailed to half of the single subscribers. If you get one, please take the time to fill it out and return it. We need to know how you would like to see us reshaped.

Results of the survey will appear in a future issue of *Park Science.*

Integrated Watershed

Continued from page 23

studies are all contracted to university scientists, some of whom already were working in the Park.

Private sector interest in Sequoia's program is evidenced by the Electrical Power Research Institute's (EPRI) funding of a study of surficial geology and mineralogy at Emerald Lake as well as by the Southern California Edison Co.'s support of both extensive lake chemistry and event precipitation chemistry.

Other studies currently or recently supported in the Park that relate directly to the ecosystem program include a Man and the Biosphere Program pilot study of dry deposition at Elk Creek; NPS Air Quality Division supported studies of ozone effects on conifers and oaks, and a survey of pollution sensitive lichens; and an EG & G National Laboratory preliminary study of trace element concentrations of air, soil, water, litter and vegetation.

Progress and Prognosis

Since the program is still in its infancy, there is little yet available in the way of hard data. Beginning this year, data and methods from Sequoia's ecosystem research program will be joined by a new research thrust to develop a Geo-based Resource Information System (GIS) that will combine historic, newly collected, and remotely-sensed geophysical and biotic information in "map" format. This will provide managers, scientists, and planners ready access to all available resource data for any given location in both Sequoia and Kings Canyon Parks. It is our hope that together with a comprehensive data base developed through the acid precipitation/watershed program the GIS will provide a model for natural resource programs in the National Park Service.

While the ultimate scope of the Sequoia program is a matter of speculation, it appears that the magnitude, quality, and accessibility of the data bases for the three primary study sites, as well as the extent of cooperation between federal, state and private interests, may prove to be the most comprehensive ever known to a National Park. Meanwhile, the effort stands as an example of what can be accomplished by combining a little seed money and a positive attitude toward the value of research.

Parsons and Graber are Research Scientists at Sequoia & Kings Canyon NPs.

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